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An Illustrated Weekly Journal

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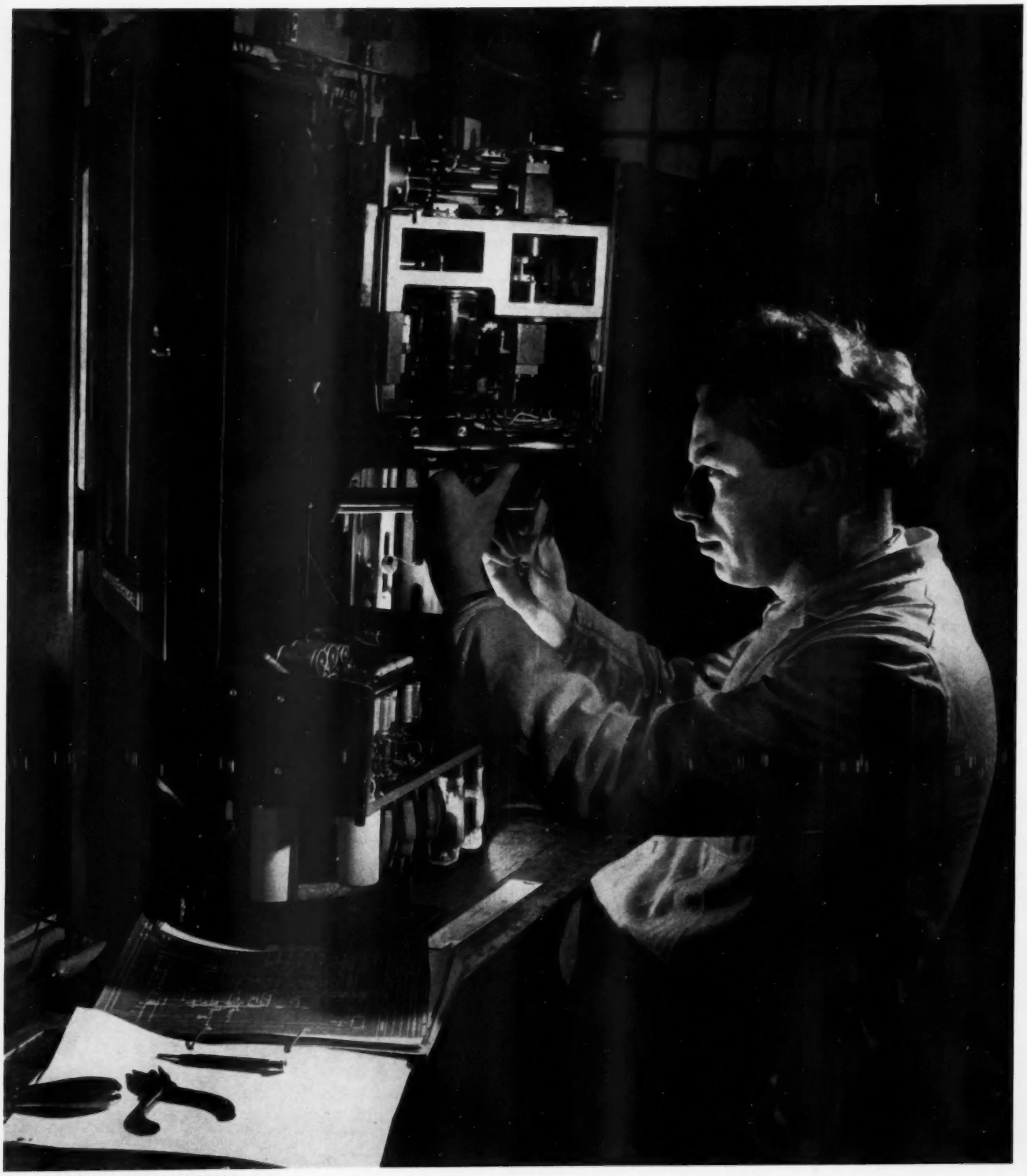

FINAL ADJUSTMENT

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STATE WITHOUT SALESMEN

WHEN a character in Arthur Miller's play *Death of a Salesman* remarks that a salesman makes nothing, builds nothing, but just gets by on "a smile and a shoeshine," he is suggesting that the work of salesmen is uncreative. He could scarcely be more wrong. Indeed, there is good reason for believing that salesmanship and advertising, together with the limited liability Acts, are the progenitors of technical civilisation as it exists to-day. The salesman does not simply meet the needs of the public, he creates needs that never before existed. The advertiser does not merely draw attention to new products, he creates the conditions in which new products can be cheaply manufactured. By establishing mass demand, salesmen and advertisers make mass production possible. They are the agents of competition and the pressure behind progress.

It would be interesting, therefore, to imagine a state without salesmen, to see how many of our present advantages it would lack. Presumably it would not advance much beyond an agricultural economy; products would be serviceable but not elegant or well finished; such technology as there was would be devoted simply to solving particular problems—how to build a bridge across a river for example. Most of modern technology does of course amount to this, but the question that defines a sales economy is not how can we achieve a given purpose, but how can we put a new discovery to practical use. The scientist may be amused to discover that the paths of electrons emitted from a heated wire can be controlled, but only the visionary sees that from there it is only a short step to telvision sets in every home. It is fundamentally the salesman who makes the step possible.

It might seem that a state without salesmen could be no more than a chimera, that our conclusions have been based on a false premise. Yet there is no place for salesmen in the fully planned economy of the Communist world. Such a state is therefore not only possible, but a fact. It follows, if our arguments are valid, that Soviet technology should be static, East German products poorly finished and Czechoslovakia should have an essentially agricultural economy. But we should be mistaken. Any Western visitor to the international trade fair now being held in Leipzig will discover that East German cars are elegant and well made, that Czechoslovakia is a modern industrial country, and that the Soviet Union is technically up-to-date; he may even remark that Soviet decoration has become noticeably contemporary in style and that Russian long-playing records—bearing jazz numbers—revolve at 33 r.p.m. He will also observe that the Hungarians have produced an Espresso type coffee machine and a version of the motor scooter. He may, however, console himself in the Bulgarian pavilion, where the graces of a less strident age are crowned by a fountain of rosewater.

But he will look long before he sees anything entirely novel, and it is clear that so far the West sets the pace. Until recently Soviet products were certainly of a rougher finish than those of the West, and some may still be, since they are designed to do a job rather than impress a customer. Thus while the engineers of the Eastern Bloc just keep abreast or tag along with Western technology, we shall have no reason to doubt the salesman's creative influence in our society. Indeed, it may be suggested that without the West to pace them and without their capitalist industrial heritage, the Communist world might never have reached its present technical eminence.

To ascertain whether or not we can be overtaken, it is necessary to examine what dynamic elements, if any, exist in place of salesmen in a fully planned economy. The five-year plans illustrate the problem-solving or target-seeking attitude to progress, but what is there to supplement this somewhat pedestrian approach? Self-preservation is a universal stimulus, particularly among leaders, but would presumably be conservative in its effect. Where power is centralised, however, the capacity for arbitrary decision may lead to important secondary dynamics. Thus, if leaders who are not scientists themselves set a high value on science, scientists achieve a considerable delegated power; vast sums are spent on scientific apparatus and to some extent the State assimilates the scientist's driving force—which is curiosity. This is partly true of the Soviet Union, where very expensive particle accelerators are being built and where practical industry is said to be unable to cope with the wealth of ideas published by research workers daily.

But there are already signs of a change; emulation of Western products seems to be leading to a taste for Western methods. Displaying a smart car on a rotating mirror turntable and allowing exhibition visitors to see themselves on television seem very reminiscent of Western consumer flattery. An official publication boasts that capitalists are legion in East Germany—a strange claim for a Communist country. It appears that the organic character of society is leading West and East to the same position—the synthesis in Marxist dialectics, perhaps.

Meanwhile, it seems reasonable to suppose that as long as the East rejects the salesman and creative selling, the West will retain its

advantage. In some respects the cost of this advantage is high: Mr. Anthony Crosland in a broadcast talk stated that in 1955 Britain spent £300 million on advertising alone. This figure, which amounts to some 2 per cent. of our national income, is, according to Mr. Crosland, the price we pay for freedom of choice. It is also the cost of technical growth.

* * *

Plain Words

Let us now praise rust. Yes, rust. We owe it some appreciation.

The conventional view is that rust is an unmitigated evil. It is blamed for the waste of eight million tons of steel annually in Britain—which is about 40 per cent. of the present annual production of the steel industry. Though there are many ways of protecting steel from corrosion, they are variously expensive and inconvenient.

To be fair to rust, however, consider what would be the consequences of its attacking something it seldom gets the chance of attacking, such as machine tools; and of being denied access to something it has ravaged for years, like agricultural machinery. Machine tools, being housed in heated and ventilated shops, used daily, frequently splashed by oil, and usually tended lovingly by an operator, are never pensioned off because of rust. They become so completely worn out, or so outmoded in performance, or such an object of ridicule (or affectionate pride), that they simply have to be moved to make room for new machines that can probably cut production costs by a substantial figure. If rust could only get at them while they were still quite young the modernisation of production systems might depend less on an accountant's fiddle and more on technical progressiveness.

The conditions of agricultural machinery are at the other extreme. Unavoidably they are left out in all kinds of weather; they become caked with dirt and vegetation. Maintenance is erratic. In spite of these hopeless conditions they thrive like children in slums, acquiring a tough skin which is almost impervious to attack. With the result that every farm seems to have one or two ancient machines which lie for most of the year as forlorn as though they were objects in a surrealist landscape. The mechanisation of agriculture has made great strides in the past few decades, but without rust it would not have been so fast.

Many methods of preventing corrosion have been developed. A firm of agricultural engineers in Essex have recently been experimenting to find the best methods for their purpose, as reported on page 331 in this issue. There is really no valid criticism of their enterprise. But the more success they and other firms and research laboratories achieve, the more necessary it will be to ensure that an unlooked-for consequence is not the prolonged use of machines that should be renewed more frequently.

Rust, rust—glorious rust !

SELLING TO THE SOVIET BLOC

THE LEIPZIG FAIR AS A GUIDE TO NEW MARKETS

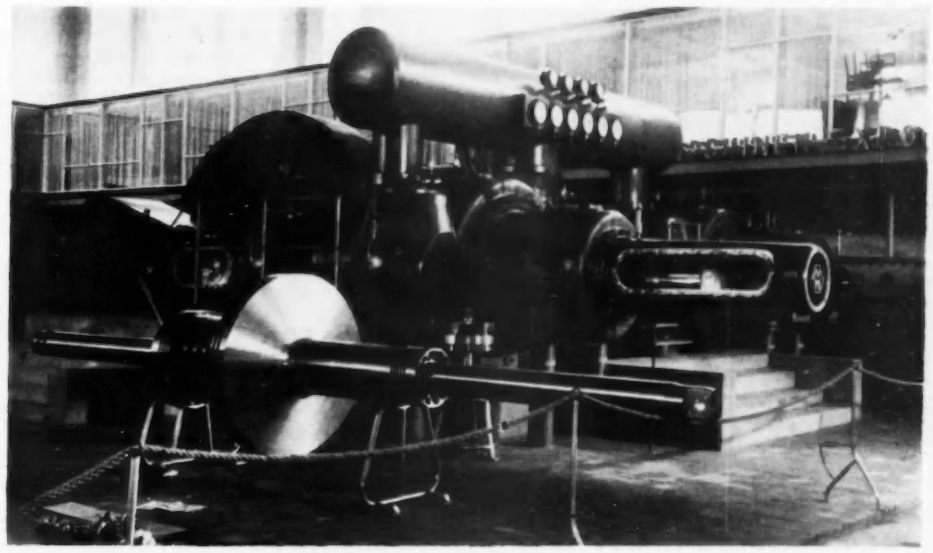
It is axiomatic that Britain's livelihood depends on selling manufactured goods abroad. Yet at present an immense area of the earth's surface is largely closed to us—a territory which, in theory at least, offers vast potential opportunities. That area embraces the countries of Eastern Europe, China and the Soviet Union, known collectively as the Soviet Bloc, and its advantage as a market lies in its current stage of economic development; this is in general intermediate between the agricultural and the industrial. The rest of the world, with certain notable exceptions such as India, is divided sharply between advanced industrial countries, which are in effect our competitors, and under-developed countries which are less in need of manufactured goods than capital investment. It follows that our national interest may well be served by selling to the Soviet Bloc, bearing in mind, of course, that commercial firms are normally in business to make money. But in taking steps of this kind, it is sometimes wise to consider " what the neighbours think ;" while exercising our commercial rights we should, perhaps, avoid offending our friends. The Leipzig Fair, which ends this week, provides some valuable pointers to the East European and Chinese markets, and in particular indicates the stage of technical development attained by each country. This factor is obviously important in determining what goods should be sent to where, and what items are best made locally. Some indication of the manufacturing abilities of the Soviet Bloc countries is given by the accompanying illustrations.

Probably the greatest barrier to East-West trade is suspicion, and there are numerous strategic embargoes which present a serious limitation to commerce. We are naturally anxious to avoid providing a potential enemy with the means to wage war on us, but it is also true that trade with China, say, will make that country more dependent on our own—if only for spares—and thus serve as a deterrent to hostile

action. Safeguards are necessary, but the position needs to be rationalised. China, for example, which would seem to offer the best opportunities both in the scope of its requirements and the means to pay, is the market most hamstrung by restrictions; the list of forbidden items is longer than for any other Communist state. It is moreover a country which superficially presents little threat to us, though there remains the problem of United States recognition of its Government. It is perhaps unfortunate that no Chinese buying delegation made an appearance at the Leipzig Fair.

The principal commercial limitation on East-West trade is the shortage of sterling in East European countries, but there are several approaches to this problem, the most familiar of which perhaps is the trade agreement. Poland, Bulgaria, Hungary and Czechoslovakia, together with Yugoslavia (which is not strictly a Soviet Bloc country), all have trade agreements with the United Kingdom, so that in effect sterling is available in those countries for purchasing British goods. Essentially a trade agreement is a bulk barter deal, and its object is to sidestep the difficulties arising from sterling shortages in the countries concerned

The Soviet Union, Rumania, China and East Germany do not have trade agreements with us and in such cases, purchase of British products may be effected directly in sterling or in some other currency such as American dollars or Swiss francs. Another approach is through the export agency, several of which—the London Export Corporation and the Dominion Export Company, for example—were exhibiting machinery and equipment made by well known British firms at the Fair. Here the procedure is simply that the same agency represents both exporting and importing companies, so that effectively the importer pays the exporter, rather like charging Peter to pay Paul. Thus, musical instruments and plant for making plastics-impregnated paper (delivery date 1959) may be imported into Britain, while specialised nylon spinning machinery may be exported in exchange. The development of a pear-shaped violin based on mathematical principles illustrates the musical enterprise still active in Germany; and the vogue for guitars created by Lonnie Donegan is an example of the British demand. It is noteworthy that Britain does not recognise the East German (or German Democratic Republic) Government, but unofficial manoeuvres are generally winked at. Export licences are not invariably required, but where an item is on the strategic embargo list, compiled by the International Consultative Committee

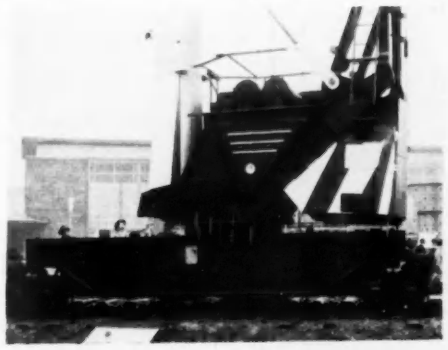


Three-stage coke-oven gas compressor of horizontal twin design, built in East Germany for Poland.

Initial pressure, 1·01 atmospheres; final pressure, 39 atmospheres. Makers: VEB Maschinenbau, Halberstadt, East Germany.

Up-to-date presentation is a feature of Soviet exhibits at the Leipzig Fair, where a GAZ Volga M21 is shown revolving on a mirror turntable.

Car: weight, 1,360 kg. (3,000 lb.); length, 4,830 mm. (15 ft. 8 in.); max. speed, 120 km. per hour (75 m.p.h.); petrol consumption, 101 litres per 100 km. (36 miles per gal.); Engine: 4 cylinders, 88 mm. bore (3·43 in.), 7:1 compression.



(Above) Rail-mounted base of rotating hammer-head tower crane, Rapid III, made in East Germany. (left) General view of crane and technical fair at Leipzig; the spire in the background is part of the Soviet pavilion. The crane, which is of light-weight construction, can be lowered into a horizontal position for transporting.

Weight lifted:

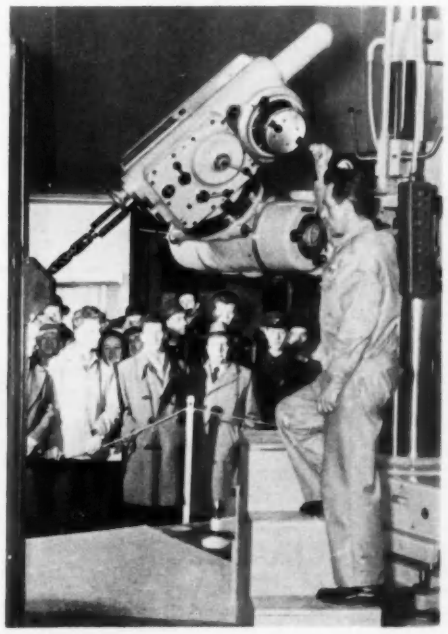
	2 tons (metric)	2·5 tons	3·0 tons	4·0 tons
at radius:	20 metres	16 metres	13·33 metres	10·0 metres

own weight, 2·45 tons; ballast, 19 tons.

Owners: VEB Verlade und Transportanlagenbau, Leipzig.

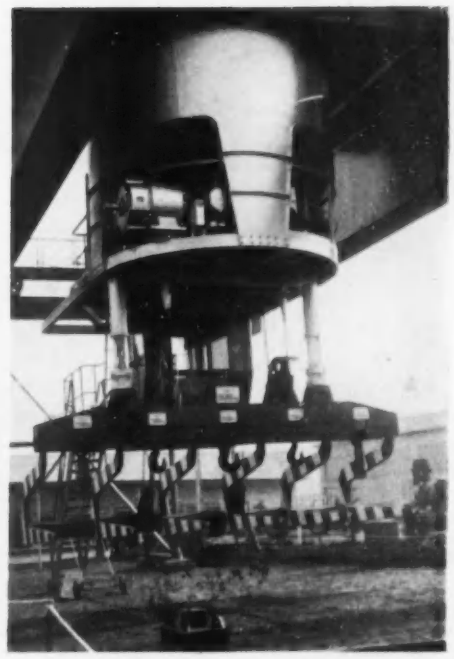
Designers: Institut für Fördertechnik (advanced technology), Leipzig.

Makers: VEB Schwermaschinenbau (heavy machine builders), S. M. Kirov, Leipzig.



The MAS VRM5O universal radial drilling machine shown in the Czechoslovak pavilion.

Max. dia. of cut, 50 mm.; drilling depth, 350 mm.; freedom of spindlestock about horizontal axis, 360 deg.; freedom of head above horizontal, 90 deg.; freedom of head below horizontal, 90 deg.; number of spindle speeds, 18; speed range, 16 to 803 r.p.m.; spindle motor: 4 kW and 1,420 r.p.m.; height of machine 3,335 mm. (13 ft.), weight 7,250 kg. (16,000 lb.).



Claw crane capable of lifting 15 metric tons. It is an example of the heavy engineering products made by the state-owned (VEB) concerns of East Germany.

Subsidiary lifts, 4 × 7,500 kg.; span, 31·5 metres; hoist distance, 6·6 metres; maker, VEB Schwermaschinenbau (formerly Bleichert), Leipzig.

(COCOM), application must be made. For example, although tractors are embargoed (they are presumably regarded as potential military vehicles) permission has been granted for large numbers of Ferguson tractors to be exported to China. It is understood that China is one of the better placed Communist states with regard to sterling resources, since she exports large quantities of foodstuffs, such as frozen eggs, to this country.

There are several other factors which affect East-West trade. An attempt has been made, for example, to integrate the economies of the Soviet Bloc countries, with the object of achieving self-sufficiency, but the defection of Poland and possibly Hungary may now have altered the situation. Thus Poland has apparently decided to export coal and steel to the highest bidder, East or West, so that East Germany, formerly dependent on the Ruhr in West Germany for these commodities and then on Poland, may suffer a serious shortage. Even China is said to have been affected by these developments. Unfortunately, coal, which it appears the East Germans are prepared to pay for in dollars or Swiss francs borrowed from other Bloc countries, is also in limited supply in Britain. National or world crises seem to create major disturbances in countries with fully planned economies; the sense of continuity is lost. Thus many East European spokesmen refer to the consequences of the Suez crisis, though there is little reference to the Hungarian Revolution, the results of which must have been far more serious for the Soviet Bloc economy.

Another consideration is currency instability and unrealistic exchange rates. For example, during the period of the Fair, exchange rates for foreign visitors have been arbitrarily doubled (from roughly 6 to 12 marks per pound sterling) and it appears that by first changing sterling into West German marks some 40 East German marks can be obtained for each pound sterling on the black market. Purchasing by Bloc countries is almost invariably carried out by a ministry delegation and this may lead to some anomalies where the ultimate user of a machine has little to say in selecting it. Sales are similarly carried out through an overall export organisation in each country. A factor that may prove significant is the choice of standards. Even China is said to be using the German metric DIN system, and will presumably prefer to buy equipment that is consistent with existing plant. There is also the problem of servicing. It is clear, too, that the first companies to break into these markets secure a valuable lead, since in engineering familiarity breeds confidence.

Next, it is important to consider the type of product likely to meet with most success in the Eastern Bloc. The first essential is, of course, to recognise the state of technical development in the country concerned; thus, scientific instruments will be of little value to people unable to use them, nor will drilling machines be welcomed by countries who make sufficient of their own. In particular, it would seem a general rule that highly specialised equipment will be in demand. Pye, for example, sold 50 fish detectors to Russia last year, and in the British pavilion at the Fair Ernest Scragg and Sons are showing examples of their textile plant, including a machine for spinning and crimping nylon yarn, with automatic control of all processes. It has been rumoured that Russia does not propose to develop new lines of textile machinery. The Pye stand was visited by a Russian delegation interested in industrial television and the company also received a Czech inquiry concerning landing aids for aircraft. The large Vickers Vigor tractor with Rolls-Royce engine was also exhibited, and flaw detectors were shown by Kelvin Hughes. The Standard Motor Company have sold nearly 300 cars and vans in Poland, and the West German Deutz air-cooled Diesel engines also created considerable interest.

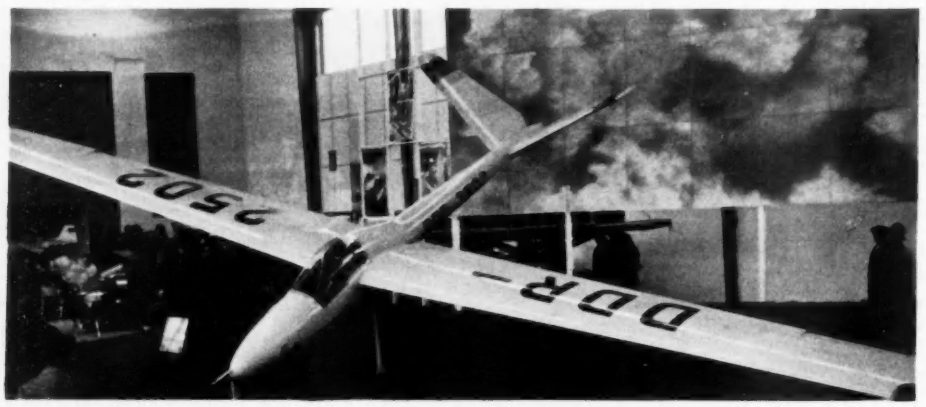
Heavy capital equipment and machine tools are likely to be required, at least for the time being. Other items which have proved successful include mining equipment such as the high-frequency (150 cycles per second) lightweight drill marketed by Victor Products, which has been ordered by Poland and China. It should be emphasised that such items may in fact be made locally, but that often in Bloc

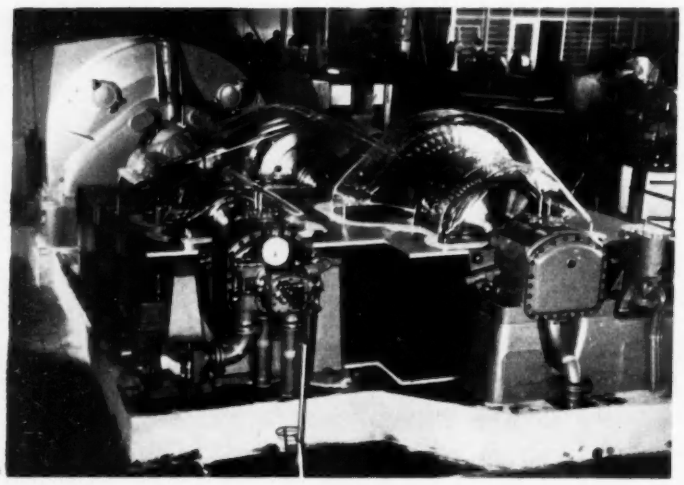
(Right) Spherical shovelling machine with Diesel generator and conveyor for bulk materials.

Maker: VEB Schwermaschinenbau, Leipzig.

(Below) LOM55 sailplane (Libelle) with dihedral tailplane. The Soviet Ilyushin XIV twin-engined airliner is also assembled in East Germany.

Sailplane: span, 16·5 metres; length, 6·15 metres; height, 1·08 metres; weight, 330 kg. (730 lb.).





Turbo-generator set with double-cased bled-steam condensing turbine. The set incorporates a novel hydraulic speed regulator shown at front of unit.

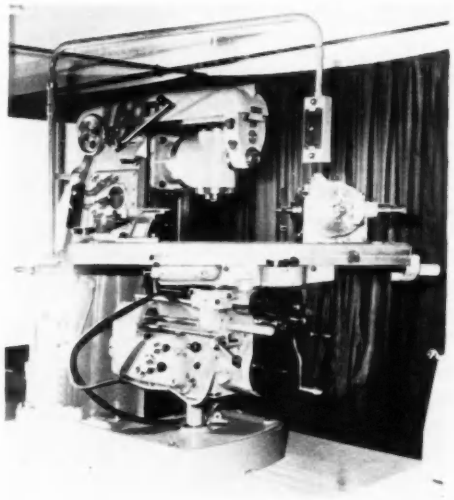
Output, 5 MW; steam conditions, 435 deg. C. (815 deg. F.) and 36 kg. per sq. cm. (510 lb. per sq. in.); turbine speeds high-pressure turbine, 7,500 r.p.m.; low-pressure turbine, 4,500 r.p.m. Maker: VEB Turbinenfabrik, Dresden.

Universal "Koordinatograph" type BAK made in Czechoslovakia. The unit is designed to trace in ink curves relating pairs of variables acting in a rectilinear co-ordinate system. For example, families of valve characteristics may be reproduced automatically.

countries there is insufficient manufacturing capacity to meet the full demand, or it is considered more economic to supplement stocks from abroad. This may be the case with East German television sets, many of which are equipped with G.E.C. cathode tubes. Similarly, China already makes steam turbines and machine tools (to vaguely reminiscent Japanese designs), but is very anxious to import more. A United Kingdom exhibitor remarked that the Chinese lack experienced engineers but are quick to learn. It is noteworthy that there was no American pavilion at the Fair.

The Leipzig Fair, which was first held in 1507, takes place twice yearly, though the technical exhibition, which was inaugurated in 1896, is a feature of the early-year session only. Trade fairs serve several purposes: for national or company prestige, as a medium for public relations, or as a market place. For Britain the Leipzig Fair is an opportunity both to display new products and also to assess the needs of Eastern Bloc countries by inspecting their exhibits Some indication of East European production is given by the accompanying illustrations, and a subsequent article will contain more detailed descriptions, together with a list of commodities East Germany wishes to purchase.

It should be noted that the letters VEB, which appear in the names of many East German manufacturing concerns, stand for *Volks Eigener Betrieb* (People's Own Industry) and indicate that the organisation, like most large firms, is state owned.



Universal milling machine "Promaiska" made in Zagreb, Yugoslavia. The machine is shown fitted with an auxiliary head.

The small tip truck made by VEB Fahrzeugwerk, Waltershausen, is one of a wide range of materials handling equipment made in East Germany.

Letters to the Editor

FIRE AT JAGUAR WORKS

SIR, Referring to your article "Jaguar's Back in Production" (ENGINEERING, February 22, page 232), many of your readers will have a professional interest in the contribution of the roof construction at the Jaguar factory to the spread of the fire, and must have been confused or misled by the conflicting statements which have been made on the subject and by the lack of any factual description of the nature of the roof construction itself. I think, therefore, they may be interested in the information set out below, which has been compiled from an inspection carried out at the Jaguar factory within 48 hours of the fire.

The fire took place in a factory which was constructed in 1939, when the roof consisted of ¾ in. fibre insulating board laid over the supporting steelwork and fixed by a specialist contractor, and over this fibreboard my firm placed the cladding of corrugated protected metal sheets.

During the war, twelve bays at the north end of the factory were damaged by enemy action, in which the whole of the fibreboard lining in this area was lost, and corrugated protected metal sheeting only, fixed down firmly upon the purlins, was restored as necessary. When the building was subsequently re-lined after the war, ½ in. natural fibreboard was placed *below* the supporting steelwork, i.e., 4 in. below the protected metal roof, thereby creating a cavity roof construction. This work was presumably carried out by a specialist insulation contractor.

The fire began at the north end of this area in a store containing large quantities of tyres and finished components, many of which were cased in wrappings or in cartons, and intense heat was generated fairly rapidly. As this heat reached the underside of the roof lining, the fibreboard took light and the flames spread along the roof lining, both inside and outside the cavity. The heat thus provided by the burning fibreboard 4 in. below the protected metal sheets set light to the outer cladding of those metal sheets, with the result that the bitumen coatings of the sheets fell on to the fibreboard before the fibreboard itself, sagging between its unsupported T's, fell to the ground. Fire spread in this way along succeeding bays at an increasing rate until it reached the thirteenth bay, which had been unaffected by bombing and where, therefore, the original over-purlin lining was intact. This lining was burned on the underside and became charred, but it was not dislodged from the supporting T's and remained in position. The protected metal sheeting above it was unaffected. Here the spread of fire stopped. We know of no factors which account for the sudden stopping of the fire-spread in the roof, except that the roof construction reverted to the original form at this point.

It is our opinion that, had the building been unaffected by bombing and the original construction remained intact throughout, even with the natural fibreboard which was the only material of the kind available at the time the factory was built, the spread of the fire in the roof would have been confined to three half bays. Had asbestos-faced insulation board or an incombustible building board been available, the spread of fire would have been even less.

What, then, are the lessons to be learned from the Jaguar experience ? In our opinion, there are three. First, where fibreboard is used to provide under-drawn insulation for a roof, it is important that it should be of the asbestos-faced type which has a Class I Spread of Flame rating. An alternative would be to use an incombustible building board. Neither of these materials was available at the time the Jaguar factory was built. Secondly, an under-drawn lining should be placed close to the external cladding, so as to avoid the formation of a cavity, along which flames can rapidly be funnelled. Thirdly, the construction should be such that the under-drawn lining is firmly anchored to the cladding material, so as to avoid the possibility of its falling in a blazing mass and so spreading fire.

These are principles which we have long advocated and practised.

Yours very truly,

C. THAIN,
Managing Director.

Robertson Thain Limited,
Clutha House,
Storey's Gate,
London, S.W.1.
March 7, 1957.

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INTRODUCING EXPLOSIVES

SIR, In his letter of February 12, published on page 228 of ENGINEERING of February 22, Mr. F. Rogers points out that the mercury fulminate cap was well known in the firearms field long before 1864 when Nobel patented a cap for the detonation of nitroglycerine. This is, of course, quite correct, but it should be made clear that Nobel's cap or detonator was not the same as that used in firearms.

In firearms, all that is needed is a quick flash to ignite the propellant charge and the process is essentially one of ordinary, though rapid, burning. To detonate a high explosive, an intense shock wave is required and this is an altogether different matter, and demands a composition which is itself capable of being ignited by flame, but which can develop an intense detonating type of reaction almost instantaneously, even when only a relatively small quantity is present. The fact that mercury fulminate could function in a percussion cap for propellants did not imply its usefulness in a detonator for high explosives, and it was the discovery by Alfred Nobel of the almost unique property of mercury fulminate in the latter respect that made possible the construction of a commercial detonator and the development of modern high explosives practice.

In Britain, it is usual to refer to the modern commercial detonator as a "detonator" in order to avoid confusion with the "percussion cap"; whereas, in America and Canada, the word "cap" is generally used. This use of the word "cap" often leads to confusion.

Yours faithfully,

I. O. LEWIS.

Research Department,
Imperial Chemical Industries
Limited (Nobel Division),
Stevenston,
Ayrshire.
March 4, 1957.

★ ★ ★

MACHINING CONICAL GEARS

SIR, Several articles describing conical gears have been published recently in engineering journals. The only way of generating these gears which I have seen mentioned so far has been that of moving the generating tool (hob or rack cutter) along a straight line including a small angle with the axis of the gear blank, whereby teeth are produced with trapezoidal sections, the top and the root being on a cone, i.e. not parallel to the axis of the gear. This process necessitates the use of a special machine and if the quantities involved are small, the cost of them may be prohibitive.

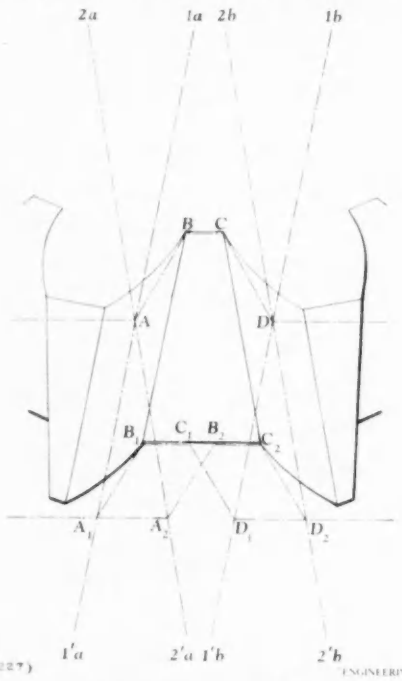
In my opinion, it is possible to produce practically the same gears on any ordinary hobbing or planing machine which is suitable for cutting helical gears, and I should be grateful if your readers could tell me whether the method described in what follows has been made known before. According to this process, the teeth require to be cut in two stages; first by cutting a

Letters to the Editor (continued)

helical gear having a very small helix angle and, afterwards, by swinging over the cutting head and generating the other side of the teeth at a similar small angle of the opposite inclination. Obviously, the tooth surfaces made by this method will be identical with those produced by the special machine referred to above, except that the boundaries of the tooth profiles will be different and that the roots of the teeth will remain parallel to the gear axis. The intersection of the teeth with cylinders, co-axial with the gear axis, will give the same trapezoidal sections as in the so-called conical gears.

This method may be made clearer by reference to the annexed illustration. Let the rack profile have the position A B C D at the top plane of the gear in cutting either side of the teeth, but let it first move along lines 1*a*, 1′*a*, 1*b*, 1′*b* into the position A_1 B_1 C_1 D_1 at the bottom plane, when cutting one side of the teeth, and along 2*a* 2′*a* 2*b* 2′*b* into position A_2 B_2 C_2 D_2 when cutting the other side.

With special cutters having a basic rack of a tooth thickness in the pitch line less than ½ pitch, such teeth can be cut without depth correction, but, within limits, standard tools can also be used, by resorting to a corresponding depth correction and stubbing the teeth. Naturally, the tapered teeth may be helical, too, i.e. they



may have slightly different helix angles on each of their two sides.

If the construction of a special machine be feasible, a planer can also be used working with two cutting tools along lines slightly inclined to each other and cutting the two sides of the same teeth (or of the same gap) at the same time, similarly to straight bevel gear planers. In this case, of course, the gear axis remains parallel to itself during its relative rolling movement over the plane of the " V " of the two cutting tools.

" Conical " gears cut by the methods here described have the same tooth geometry as the conical gears proper, except that they have a constant root circle radius. The outside of the gear blank may be either cylindrical or conical. With some limitations, such gears can be used for practically the same purposes as the " conical " gears, and may even be more advantageous for certain purposes, such as for adjustable backlash.

Yours faithfully,
V. LEHEL.

209 Olton Boulevard East,
Birmingham 27.
March 5, 1957.

THE EARLIEST ROLLER BEARING

SIR, I desire to refer to Mr. J. T. Emmerton's letter on page 292 of ENGINEERING of March 8, headed " How Old is the Roller Bearing? "

It seems to me that the bearings found on the hubs of the wheels for the Dejbjerg wagons (Fig. 1 of Mr. Emmerton's letter)* are not true roller bearings, although they might be described as a close approach thereto. Moreover, according to the information I received from Mr. Ole Klindt-Jensen, of the National Museum in Copenhagen, the wagon shown in the illustration was made in the first century B.C. It appears, therefore, that the roller bearings of Diades (about 330 B.C.) were the earliest to be recorded, as I stated in my article " Bearings Since the Stone Age," published in ENGINEERING of January 4, page 2.

If I may, I should like to quote from Mr. Ole Klindt-Jensen's book† :

> " The axle bearing has a number of longitudinal grooves close together, rather worn but clearly round. When discovered there were cylindrical sticks in the grooves. The excavator considered they had served to reduce wear, but to me it is more probable that they rotated with the wheel and thus acted as a roller bearing like the modern device. They could scarcely be capable of preventing much wear."

This statement clearly shows that there is a divergence of opinion between the author and the excavator: the author, Mr. Klindt-Jensen, saying that they were roller bearings and the excavator saying that they were not.

Yours faithfully,
C. ST.C. DAVISON.

Science Museum,
South Kensington,
London, S.W.7.
March 8, 1957.

* The illustrations which accompanied Mr. Emmerton's letter were reproduced by the permission of Mr. Ole Klindt-Jensen.

† *Foreign Influences in Denmark's Early Iron Age*, (English translation), page 89. Ole Klindt-Jensen, 1950.

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MOTOR-CAR STANDARDISATION

SIR, I have noted the comment you sent me upon what I said in the House of Commons. (Plain Words, ENGINEERING, March 1, page 258).

I hope that you read the speech carefully because I was referring only to under-the-bonnet standardisation. We have still a very long way to go in the standardisation of components, which is where the American industry scores so heavily. From these standardised components it is possible to build apparently varying models as a child can from a Meccano set.

What you seem to forget is the immense disparity between the number of makers in this country and America in relation to the output. This is a critical factor which cannot be ignored—save, perhaps, by apologists.

Yours faithfully,
WILLIAM SHEPHERD.

House of Commons,
London, S.W.1.
March 5, 1957.

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AN ENGINEER'S CARD INDEX

SIR, Having given myself a very large card indexing job of the sort discussed by Mr. R. Silvester in your issue of January 11, page 38, and by Mr. J. E. Holmstrom in your issue of January 25, page 101, I would like to add to their discussions from my own experience. I am chiefly concerned with economising the time spent by the indexer. It is my practice to maintain a duplicate file, indexing once according to the source and once according to the subject. I have found that only the source file can be nearly fool-proof for positively identifying a particular item. My source file would correspond, generally, to Mr. Holmstrom's author file. However, in the fields I am interested in, the source is generally much more significant than the author(s), owing mainly to the multiplicity of authorship for any single enterprise.

After I have made out two reference cards for each item, I have done as much printing or typing as I care to do, and am anxious to complete the work with the least effort. In practice, I have found it best to sort subject cards under the broadest possible subject headings consistent with a reasonable stack of cards for each, say 25 to 100 cards to a stack. Whenever a subject heading becomes backed up by too many cards, I subdivide the heading and then subdivide the cards. I sort the subject cards much as one might grade apples or lumber, rapidly and liable to some imperfection, but with a fair assurance of avoiding gross errors.

When the time comes to use the subject file, the breadth of my search is determined by the subject of interest. Perhaps it is necessary that I must go through only one stack of cards, because I am quite confident that the information I require can be in only one place. On the other hand, it may be that I must go through half-a-dozen more or less neighbouring stacks, because, possibly, of inaccurate filing in terms of the particular item of current interest. Once in a very great while, I may want to go through as many as 2,000 source cards, if the subject of interest is very broad in terms of my usual subject categories. Such an approach can be very revealing in defining what the subject of interest really amounts to, according to the well-recognised attributes of " browsing." (This browsing aspect, I believe, is of special relevance to the great activity now taking place in the field of documentation for special libraries, where emphasis is centred rather upon *telling* the library patron what he wants, than upon giving him free access to as wide a field of reference as he cares to use.)

More important, however, than these considerations, the task of running through the subject cards is remarkably quick—very much quicker than prior cross-referencing would have been. Furthermore, I avoid the annoyance of turning up the same subject card more than once and having to weed out duplications. Non-professional drudgery associated with the maintenance of the file is limited to preparing the two cards for each item, to sorting the source file cards by source, and to sorting both types of cards chronologically behind their particular file headings.

Very truly yours,
GILBERT S. BAHN.

22816 Pacific Coast Highway,
Malibu,
California, U.S.A.
March 5, 1957.

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SHIPBUILDING DISPUTE

SIR, I feel that your comment under the heading " Patchwork in Shipbuilding " (The Human Element, March 1) is the result of your failing to check the " patchwork reporting " of the national Press. The dispute over the payment of lieu rate for " stand-by " arises from an agreement with the Mersey Ship Repairers' Federation, of which we are not members.

We are endeavouring to negotiate settlement of an entirely separate issue with the boilermakers, and they are using " guerrilla " tactics in preference to procedure.

Yours faithfully,
For and on behalf of
Cammell Laird & Company
(Shipbuilders and Engineers) Limited,
R. B. WIGHT,
Personnel Director.

Birkenhead.
March 11, 1957.

Weekly Survey

Cover Picture:—*The high-speed electronic recorder, one of which is shown in our illustration undergoing final adjustment, has been developed to meet the requirements of making accurate records of variables which have high rates of change. The type shown was designed primarily for research in infra-red spectrometry, but present applications include absorption meters and temperature measurements.*

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Tackling the European Market

What happens when a medium-sized engineering firm tries to break into continental markets? Is the effort worth while or is it just throwing money away? These are questions that will be asked increasingly in the next few years if the free trade area and common market schemes are realised. Some of the answers are given in an article in the *Board of Trade Journal* by a director of a Midland company making thermostatic mixing valves for hot and cold water. This firm, which employs 300 men, had sold its product on the Continent through agents without making any special effort to increase sales. In 1948 the company decided to build up exports to 10 per cent. of the value of home trade. For a start Switzerland was chosen as representing a compact market, where demand for the product was known to exist. The company found a representative by advertising in Swiss papers and brought him to England for a month's training. Then the director concerned and the representative toured potential customers for a week after which the representative was left to get on with it. By the end of 6 months, orders were enough to cover expenses, namely, salaries of representative, a clerk and a part-time bookkeeper, office rent, advertising and a car. Over the next two years an advertising campaign with carefully translated pamphlets was carried on. The director made regular visits of 10 to 14 days to Switzerland.

The main problems were connected with quality and service for both of which pre-war standards were required. Delivery dates considered good in England were not acceptable to the Swiss. Inspection and testing were improved. Shipping methods and routes were overhauled. After 2 years expenses amounted to 59 per cent. of net sales. Competition with a cheaper Swiss pump was met by improving quality and service. Since the end of the third year the target for sales has been reached regularly. The cost of success has been quite modest. The Swiss branch cost £4,000 in the first year and has since risen to £6,000 for all outgoings. Since then the same firm has applied the same methods in the German and Belgium market. The recipe—a few thousand pounds, determination, hard work and maintenance of standards of quality and service—should not be beyond the reach of any enterprising British firm.

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The 100,000 Ton Tanker

Deutsche Werft, Germany's leading shipbuilding concern, is the latest company to announce the provision of facilities for the construction of tankers of over 100,000 d.w. tons. The company has a slipway under construction 900 ft. long and 165 ft. wide at a cost estimated at between £4 and £4·5 million, including plant for handling and processing heavy plate. The company has had inquiries from Greek-American interests for two 130,000 ton vessels but no order has yet been accepted. In announcing this, the chairman stated that he would not advise any shipowner to build such tankers until dock installations are adequate to receive them.

The main impetus towards the employment of giant tankers of this order of size, as opposed to supertankers of 24,000 to 50,000 tons arises from doubts as to the future of the Suez Canal after clearance has beeen effected. It has been estimated that for transporting Middle East oil to North West Europe round the Cape a tanker of 80,000 to 85,000 d.w. tons is needed if costs are to break even with those of a 40,000 tonner passing through the Canal. The big tanker could not in any case use the Canal unless the latter were enlarged in width and depth since the limit for tankers capable of passing the Canal, even part loaded, is about 65,000 d.w. tons carrying 50,000 tons in all.

There is at present only one tanker in service of over 50,000 d.w. tons, namely the 85,000 ton Universe Leader, but at the end of 1956 there were under construction nine vessels between 50,000 and 60,000 tons, 17 between 60,000 and 75,000 and eight over 75,000. By the end of February, 1957, three vessels of 100,000 d.w. tons were on order in the United States and Japan and one of 106,500 tons to be built by the Bethlehem Steel Company who are said to be preparing designs of vessels in the 120,000 ton range. Nevertheless these very large vessels represent in aggregate only a very small proportion of the tanker tonnage on order; the number of these which can be built in the next few years is strictly limited by the size of berths available.

Meanwhile steps are being taken to expand a number of oil ports to accommodate bigger ships, such as at Finnart for the Grangemouth refinery, at Milford Haven for Llandarcy and at Tranmere for Stanlow. At Le Havre, a new oil berth is planned for tankers up to 140,000 d.w. tons and similar plans exist for deep-water berths on the Mediterranean from which a large area of Europe would be supplied by pipeline. From 1960 onwards vessels of over 60,000 d.w. tons could form the bulk of tankers on order.

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Boom in Petroleum Equipment

The British petroleum equipment industry, whose establishment virtually dates from the immediate post-war years, is now enjoying boom conditions and making a substantial contribution to total British exports. According to figures recently issued by the Oil Companies' Materials Secretariat, orders placed with the United Kingdom industry in 1956 reached the record figure of £153·7 million compared with the previous year's total of £123·5 million. Orders for export are estimated to have amounted to £130 million in 1956 compared with £100 million in 1955.

In the immediate post-war years considerable doubts were expressed regarding the industry's long-term future since it was thought that the market for British equipment would decline once the first wave of refinery expansion had been completed or the dollar shortage had eased. In practice, except for slight recessions in 1953 and 1954, output has expanded in each year since the war. The main reasons for the increase in orders during the past year have been a new programme of refinery expansion throughout the Free World and to intensified exploration activity in countries other than the Middle East. In the Free World outside the United States, 25 new refineries are in course of construction or about to be built; a further 11 new plants are also projected and 22 existing refineries are in course of expansion.

It has been stated that United Kingdom manufacturers are now in a position to supply almost a complete range of refinery equipment and about 80 per cent. of the equipment needed for a new drilling venture. Of the orders placed in 1956 tubular goods, pipe fittings and valves accounted for £35·7 million, chemicals and catalysts for £24·6 million and oil-exploration and development equipment for £15·3 million. The main factor restricting the output of the industry is shortage of steel and no great improvement in this respect is anticipated before 1960. This is unfortunate because it is causing long delivery delays and is resulting in the diversion of orders to other countries, particularly Germany, where a strong competitive industry is being developed. The industry has also developed in Belgium, France, Holland and Italy. There is also a tendency for local competition to develop in a number of countries, for example, Japan and Australia. The indications are, however, that all manufacturers are likely to be assured of full employment for some time to come and the British industry in particular is likely to command a strong position owing to its accumulated experience and the advantage of low steel prices.

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New Ideas Pay Their Way

A few years ago a United Nations publication on the European economy stated that more than a quarter of the goods covered by world statistics in 1950 did not exist at the beginning of the century. What these new products are and the part they play in the United Kingdom economy are explained in an article by Mr. G. L. Rees in the current issue of the *National Provincial Bank Review*. " New " products are those which had only negligible pre-war earnings, while " virtually new " products had export receipts of under £10,000 in 1938 and over £400,000 in 1955.

Engineering products in the " new " category are led by radio-communication and navigational-aid equipment, exports of which amounted to £2¼ million in 1948 but had passed £12 million in 1955. Television transmitters and receivers rose from £38,000 and £4,000 to £335,000 and £492,000 respectively. Cathode-ray tubes, industrial radio-frequency equipment, tape recorders, floor polishers, combine harvester threshers, fork lift trucks, Diesel locomotives and electric furnace plant all appear in the " new " list. Of the " virtually new " products the most successful have been tracklaying tractors, with exports worth £504,000 in 1948 but £4½ million in 1955.

The main fact emerging from these lists is that one of the principal exports from the United Kingdom is new ideas. Our best chance of competing abroad is probably in developing items which are not sold in sufficient numbers for mass production on the grand scale but which still comprise an important international market. The fact that a high proportion of the sales of these products is to the European market is not without significance for the future. The United Kingdom products in the " new " and " virtually new " lists are supplied almost entirely by the engineering and chemical industries. Continental countries have quickly shown themselves able to produce new medical products—the antibiotics and the sulphonamide drugs—for themselves. This has not been the case with the newer engineering and electrical products.

Success has not been confined to Europe: exports of new products to the Sterling Area markets rose from 48 per cent. of the total in 1953 to 52 per cent. in 1954. New ideas pay, but the price of success is that Britain must invest in research and development on an increasing scale.

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Brains at a Premium

The need for more scientific and engineering manpower is by now a well worn topic of discussion, and the production of engineers is referred to in almost the same way as if engineers were an industrial commodity.

In an article in *The Times* last week, Sir Solly Zuckerman, Chairman of the Scientific Manpower Committee of the Advisory Council on Scientific Policy, reviewed the estimates which have been made of this country's requirements and capacity for meeting them.

While steps are being taken both by the Government and the Universities to meet this

great increase of demand—notably by the encouragement of sandwich courses and the associated Diploma of Technology—a great deal of re-thinking is needed in schools. At present the proportions of science specialists in schools are approximately 60 per cent. in boys' grammar schools, 30 per cent. in girls' grammar schools, and 50 per cent. in boys' public schools. Yet, in spite of the high proportion of all science graduates employed in teaching, only one in four teachers in grammar and public schools teach mathematics or the sciences.

The time has surely passed when the humanities only were regarded as education, and the sciences were to be studied only from base utilitarian motives. The concept of engineers and scientists as units of production obscures the important fact that for survival in the present world, an increase of skill is required at all levels. If the advances of modern civilisation are not to be largely wasted, the acquisition of engineering and scientific skills must be regarded not as a necessary evil but as a part of education for living—and surely this need not be regarded, as it still too often is, as excluding that general education which is becoming even more important.

" A hairy man is the engineer,
His food is axle grease and beer."

is as wrong now as it always was. It is to be hoped that the attitude which engendered this proverb will not only be quickly killed, but unceremoniously interred.

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Expensive Trial and Error

It is perhaps to be expected that the Ministry of Supply should be on the defensive as to aircraft expenditure. The Comptroller and Auditor General's account of the £40 million expenditure on Swift aircraft makes in retrospect sorry reading, and a catalogue of errors which, after the event, seem as if they could easily have been prevented or at least lessened. Total orders rose to 492 in August, 1953, and though no further orders were placed, it was not until the time of the Ministry and R.A.F. evaluation of the Mark 3 early in 1955 that it was decided that the major defects of the aircraft could not be effectively remedied, and orders were reduced to 170. Some years before this, both the Royal Aircraft Establishment and a United States evaluation team had made discouraging assessments of the aircraft's performance.

Facts about aircraft development, though sometimes deplorable, are rarely simple. It must be remembered that the Swift was ordered in a hurry under the shadow of Korea. This may well be the root of the trouble. As Sir Arnold Hall stressed in the Wright Brothers lecture last December, the Mark I in any series is almost always disappointing. Short cuts and stopgaps to make up lost ground are unlikely to succeed.

Considerations such as these make the choice of defence cuts an unenviable task. It was announced last week that at the same time as the de Havilland Gyron had passed type approval tests at a static thrust of 20,000 lb., Government support would probably be discontinued. If no British aircraft is likely to be ordered which might use it, this is natural enough, but on such developments as these depends the future of British aircraft exports. Both the United States and France are reported to be interested in the engine, and it is good to know that de Havilland have sufficient faith to continue development as a private venture. With dwindling defence expenditure, sale of aircraft and engines must be looked at on a world-wide basis, and it is only to be expected that development costs must be borne increasingly by the manufacturers. How far they can succeed against United States manufacturers bolstered up by large military orders is more doubtful.

Giant of Steel

The public have had on offer this past week—from March 11 to March 14—37 million £1 ordinary shares of the Steel Company of Wales, with the expectation of a dividend of 8 per cent. Two million shares have been taken by Guest, Keen and Nettlefolds and one million by the Metal Box Company, making 40 million shares in all.

The post-war pride of the British steel industry, the company are now over half-way through their development plans, having spent about £115 million of the projected £177 million. Output last year was 1·7 million ingot tons; it is expected to rise to 2·0 million tons this year, 2·4 million tons in 1959 and 3·0 million tons in 1961. They have the largest and most up-to-date integrated plant in the country, supplying a very wide spread of industry. Their biggest customer is the tin-plate industry, which has one of the fastest expanding markets for its products. Although SCOW are important suppliers of motor body sheet less than one-third of their output consists of sheet and less than half of this goes to the car industry.

This issue will be of considerable interest to the engineering industry, for its reception will show how far the investing public (and of course the institutional investor) is willing to take a political risk to back one of the most basic units in a basic industry. Steel, like chemicals and most other raw materials, should leap ahead during the next decade. Criticisms of the industry have always been plentiful. To-day there is much resentment among plate users, and also among users of alloy steel, on the ground that their requirements are not being met and that the steel industry is making most inadequate provision for their future needs. The point established most forcefully by the SCOW figures and forecasts is that it is difficult to make adequate provisions for expansion out of income; the 8 per cent. dividend and distributed profits tax thereon, will take £2·7 million, which is rather more than half the anticipated net profit. The estimated trading profit for 1957—£16 million—amounts to 11 per cent. of total capital employed which includes £65 million of debentures held by the Iron and Steel Holding and Realisation Agency and some £40 million of short-term loans required for the company's expansion programme. It is in the 1960's, when trading profits are expected to exceed £25 million, that the company's full potential will be realised. If all goes well indebtedness will have been substantially reduced and the holder of ordinary shares should have earnings of not much less than 30 per cent. a year.

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Trend of Profits

The profits of the 310 companies whose reports were published during the first two months of this year show an increase of 4 per cent. over the same period in the previous year. The *Financial Times* analysis reveals that only in four industries—motors, paper, shoes and household goods—have profits lagged behind last year's level. Although these include two most important engineering groups, the performance of other sections of the engineering industry is most encouraging. They were 11 per cent. higher and those of shipbuilding 5½ per cent. higher. On the other hand the number of reports received so far is less than 10 per cent. of the annual intake and the general picture may alter as the sample becomes larger.

Several companies whose reports were published last week bear out the improvement revealed by the *Financial Times*. International Combustion (Holdings) Limited record an increase of over 13 per cent., to £1·8 million; the Streetly Company, Limited, were 25 per cent. better, to £1·4 million; the Universal Asbestos Manufacturing Company, Limited, about 4 per cent. better to £0·4 million. International Combustion's chairman, Mr. G. R. T. Taylor, reports an increase in the output of the group " achieved against a continuing background of material shortages which, in certain classes of steel, still remain acute." Their substantial liquid resources are to be used " in expanding the company's business in fields either closely allied to its main interests or complementary to them."

The Streetly Company, who are one of the largest producers of refractory materials to the steel and other industries, recorded substantial increases in output and productivity. Over the past eight years the company's productivity has risen by 65 per cent. (higher than any industrial average) and the amount invested in fixed assets has risen from £1,142 per man employed in 1946 to £4,729 in 1956. The chairman of Universal Asbestos, Mr. Frank W. R. Douglas, considered that " with our increased manufacturing facilities we shall once again produce results which will do us credit." The company supply their products to a very wide field of industry; their performance and confidence in the future reflects fairly accurately general industrial and economic conditions.

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Car Component Business

Three large suppliers to the motor vehicle industry, the Birfield Group, British Tyre and Rubber, and Triplex Safety Glass—and the largest producers of heavy road vehicles, Leyland Motors—had interesting progress to report last week. Birfield's chairman, Mr. Herbert Hill, revealed that 62 per cent. of the Group's £17 million turnover in the last financial year was accounted for by deliveries to the motor industry and nearly 25 per cent. consisted of general engineering components and products. The extent to which they are involved in transport engineering is further underlined by the fact that 14 per cent. of sales were to railways, aircraft and garages. Mr. Hill announced that a new company, Birfield Industries, Limited, now handles all selling for the group's 17 manufacturing units.

British Tyre and Rubber reported substantially lower profit margins and increased competition. The group's trading profits were down 18 per cent. to £1·8 million. Their chairman, Sir Graham Hayman, placed considerable emphasis on increased competition, quoting the passing of the Restrictive Trade Practices Act " as a significant influence on trading conditions in this country " and the proposals for this country's participation in a European free trade area as opening up " a prospect of profound development." But both will give rise to substantial problems of adjustment and adaptation which will tax the resources of most companies. Both B.T.R. and Triplex have substantial expansion schemes in progress. An interim report by the directors of Triplex states that despite penal taxation on motoring and the recent troubles experienced by car manufacturers—which will have " a natural repercussion on the current year's profits "—that the Board believe " the future demand will need the full expansion schemes launched a year or two ago." Expansion into the aircraft and television industries on the safety glass side and, through their subsidiaries, into chemicals and engineering, has substantially reduced the company's dependence on motor vehicles.

Leyland Motors report a group trading profit of £5½ million for the year ending September 30, over £1 million higher than the previous year. The company's success, shared to some extent by other heavy vehicle builders, has continued during the past six months. Like Birfield, they have integrated all sales and service arrangements of the three principal units in the group—Leyland, Albion and Scammell. More than ever before, for all those in the motor vehicle field, success depends on first-rate world-wide service.

PREPARING A SPECIAL CERAMIC

MECHANICAL HANDLING WITH SOME PARTICULAR PROBLEMS

K.L.G. Sparking Plugs, Limited, a subsidiary Company of Smith's Motor Accessories, Limited, London, N.W.2, began to manufacture their "Hylumina" hard, heat-resisting ceramic some two years ago in their factory at Treforest, near Cardiff. When production started plant designed for making another type of ceramic was used. Hylumina has now superseded the other material, and completely new plant has been brought into full production.

Hylumina (the characteristics and uses of which were described in ENGINEERING, December 23, 1955, page 864), is a hard ceramic with electrical, thermal and wear-resisting properties which render it suitable for many other purposes besides the manufacture of sparking plug insulators, for which it was originally developed. It is moulded and shaped in several ways and fired at over 1,600 deg. C., after which it is ready for use. Preparation of Hylumina ready for moulding is largely a matter of mechanical handling, but its nature is such that the handling is not quite so straightforward as might be expected.

CLEANLINESS AND ACCURACY

The major constituent of Hylumina is aluminium hydrate (Al_2O_3, $3H_2O$). This has to be handled in bulk, and very small quantities of other materials have to be added at the appropriate points in the manufacturing sequence. Water is also added at more than one stage in the process. It is very important that there should be no possibility of contamination of the material by foreign matter, and the proportioning of the material in the various stages of manufacture must be to a high degree of accuracy. Saving of time and labour are of obvious importance in any mechanical handling layout, and these factors have also been given due consideration. The new plant produces about 6½ tons of Hylumina a week, and this involves handling about 10 tons of raw materials in the early stages, as there is some change in weight during processing. This output has been achieved with a labour force of six men in place of about 20, who were needed to operate the old equipment.

The principal raw material, aluminium hydrate, is received by road, and is unloaded straight from the vehicle to the boot of a bucket elevator, which lifts it to a horizontal screw conveyor feeding four storage bunkers. All parts of the elevator, conveyor and bunkers which come into contact with the material are made of aluminium, so any metal particles which may find their way into the bulk material as a result of abrasive wear, will be converted into aluminium oxide (Al_2O_3) at a later stage in the process. The elevator and conveyor bearings are of nylon, used dry, thus eliminating another possible source of contamination. Similar elevators, conveyors, storage bunkers, handling hoppers and containers are used throughout the process, aluminium being an ideal material of construction since it is harmless to the material being processed.

An overhead track extending beneath the line of four bunkers carries a hopper-type weighing machine which can thus be traversed to the point required for receiving a charge of material. Likewise, it can be traversed over a set of five ball mills, which are in line with the bunkers and discharge its load to whichever mill is ready. Feed from the bunkers is through two short lengths of screw conveyor, one length serving two bunkers, and the weighing machine, which is of the lever and proportional-weight type, cuts off the power to the feeder when the correct load is in the hopper. This is done by the rising of the scale lever, which makes contact with a micro-switch mounted on the fixed supports for the bunkers. The weighing machine capacity is 200 kg., and its accuracy 0·01 per cent. Two scale charges make up a grinding mill charge. Water is metered into the 400 kg. mill charge and the necessary very small weighed quantity of catalyst is added by hand at this stage.

WET GRINDING

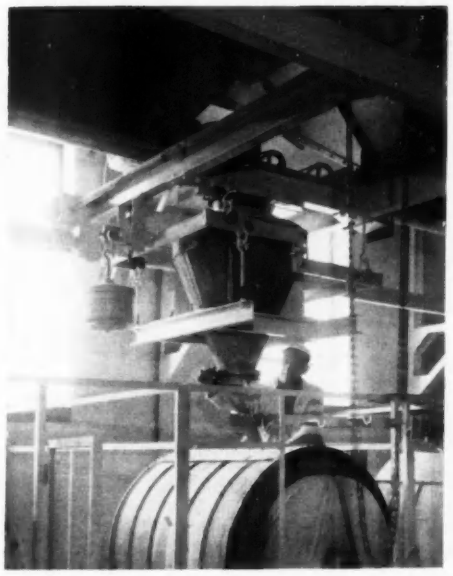
Grinding in the mills, which are rubber lined, is effected by balls of Hylumina, which is not only an effective grinding medium by reason of its hardness, but is also an obvious answer to the problem of contamination. The grinding is on a time basis, being of 16 hours duration, and since the weights of the material are constant, the result is a consistent product, or slip, from the mill.

The slip is pumped by reciprocating pumps from the mills to a filter press, the pump rams being of Hylumina, and the filter cake is stripped from nylon press cloths ready for the next operation.

CONVERSION TO AN OXIDE

When the material leaves the filter presses it is thixotropic, or the reverse of plastic, and it cannot be extruded or machine fed in the manner of a clay ceramic. At this point, therefore, it is necessary to deal with the material by hand, the only point in the production sequence where this is so. It is placed by hand in small rectangular saggars, which pass along a roller conveyor to the charging end of a continuous kiln. Here the saggars are stacked on a kiln car, and every four hours one of these cars is pushed into the kiln. A hydraulic ram gives a steady traverse to the cars in the kiln, and the cycle time is 48 hours. The kiln is gas-fired, with automatic control and has a maximum temperature of 1,040 deg. C.

In this kiln the material is converted from the aluminium hydrate form ($Al_2O_3 3H_2O$) to that of an aluminium oxide (Al_2O_3) by the removal of the water of crystallisation. This involves a loss of weight of some 34 per cent. The calcined



The first stage in preparing Hylumina is weighing predetermined charges from overhead bunkers to a line of ball mills.

After grinding, the raw material is calcined in saggars in a continuous tunnel kiln. A car-load of saggars is here discharged into an elevator.

Very fine grinding, to micron sizes, is done in a group of fluid energy mills or micronisers which work by air-induced attrition.

After grinding, mixing with certain other ingredients and drying, the material is finally mixed with a predetermined quantity of water to adjust its moisture content to the required figure.

product is an aluminium oxide consisting of fine crystals of the natural flat shape.

The saggars are emptied into the boot of an elevator which, with a horizontal screw conveyor, feeds three storage bunkers. Empty saggars are returned for re-filling on the roller conveyor previously mentioned. The bunkers are out of sight of the operator emptying the saggars, and each is fitted with an electronic level detector, the three being controlled from an illuminated diagram panel adjacent to the elevator boot. Interlocking prevents incorrect operation and the elevator drive is stopped automatically if all three hoppers are full. Once again aluminium is the metal used in the construction of the elevator, conveyor and bunkers.

GRINDING TO MICRON SIZES

From the storage bunkers the calcined material is fed by a vibrator to an auxiliary hopper, and thence by gravity to a small claw-type crusher. It is now a powder, but it is required in a much finer state, so it is blown by air to one of three fluid energy mills or micronisers. These are among the most interesting items of plant in the factory.

The material is ground entirely by attrition, the mill having no moving parts. It consists, basically, of a shallow, cylindrical drum, mounted with its axis vertical, and having round its circumference a number of compressed air jets set tangentially to a theoretical circle within the drum. Material, which is fed in from the top of the drum, off the centre-line, tends to be driven inwards by the rotating body of air set up by the jets, and as it rotates with the air centrifugal force tends to throw it outwards. This continual conflict of two forces causes the repeated contact of the particles, which are thus broken up. When the particles are small enough their mass is so small that the effect of the air flow overcomes that of the centrifugal force, and drives the particles inwards to a central discharge tube down which they travel in an air vortex. Restriction of the discharge tube at the bottom breaks the vortex and most of the particles fall away by gravity. The air returns up the tube inside the descending vortex, and is taken away on the axis at the top to a dust extractor. Some of the smallest particles go with this air, and they are recovered in the dust extractor to go with the bulk of the material to the next stage in the process.

From the micronisers the ground material passes to wheeled portable hoppers, which are filled to contain about 300 kg. This weight, which is checked on an adjacent dial scale, is varied slightly to suit the next stage in the process, which is the addition of Bentonite and water. The moisture content of Bentonite varies in each batch received, and the proportion of aluminium oxide is therefore varied accordingly to obtain the required total water content. An electric hoist enables the portable hoppers to be lifted over a line of five ball mills, which are similar to those used earlier in the production process, and here the weighed charge of aluminium oxide and Bentonite is milled with a metered quantity of water. Filter pressing follows, and the material is then dried on trays in steam or electric batch-type ovens, prior to final adjustment of moisture content ready for processing.

In accordance with usual practice where a closely-controlled moisture content is necessary, the material is first dried completely and then mixed with a measured quantity of water. In this case the material is passed through a disintegrator to break it up after drying, and then made up into a weighed charge with a predetermined amount of swarf or powdered material recovered from the subsequent shaping operations. Finally, the charge is fed by skip to a mixer, where it meets a metered quantity of water sufficient to raise its moisture content to 8 per cent. On discharge from the mixer, and after passing through granulators, it is in the required state of plasticity and is ready for moulding.

SHAPING AND FINISHING

All Hylumina components are formed, generally speaking, in the same way. They are first moulded to the approximate size and shape required, an allowance being made for finishing. Sizing is by turning or form grinding, after which the products are placed in saggars and fired at 1,650 deg. C. After firing, the material is ready for use, and is so hard that it cannot be altered in shape in any way, except by grinding with a diamond-impregnated wheel. The machinery used in the moulding, shaping and sizing of the many different Hylumina components is all of K.L.G. design and manufacture, and extensive development is taking place in this section of the works.

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INERT PLASTICS FOR GASKETS, DIAPHRAGMS AND PACKINGS

Among their manufactures, Richard Klinger Limited, Klingerit Works Sidcup, Kent, have produced for the past 25 years sleeve-packed cocks for use in high-temperature high-pressure steam installations and also for services in connection with many other liquids and gases at high pressures. The cock depends for its tightness upon a renewable sleeve of compressed asbestos which is inserted in the body of the cock as a single unit. A ridge down one side of the sleeve fits into a corresponding groove in the body, thus ensuring that the sleeve remains in place with its ports always in line with the passage through the cock body.

The sleeve-packed cocks are made in various sizes from ¼ in. to 1 in. full bore and the compressed asbestos sleeves have worked satisfactorily with steam at a pressure of 850 lb. per sq. in., and a temperature of 900 deg. F., with saturated steam at 2,000 lb. per sq. in., with benzine at a pressure of 3,000 lb. per sq. in., and with various gases and liquids in chemical plant at pressures of up to 6,000 lb. per sq. in.

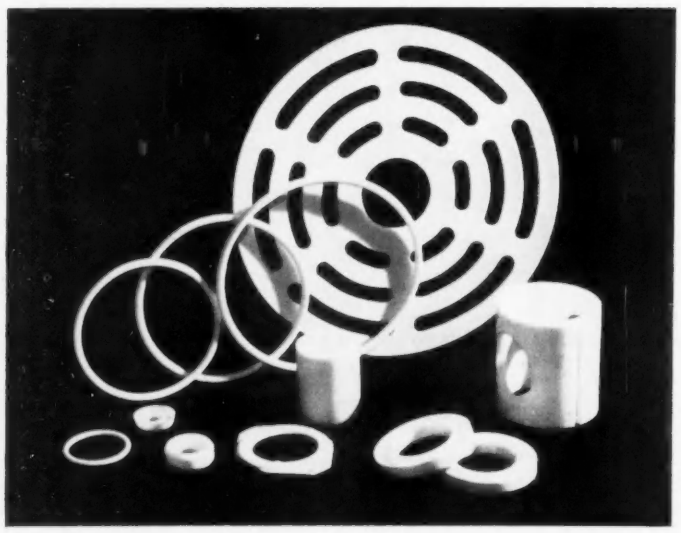
For use in connection with strongly reactive or particularly corrosive liquids a more inert material than compressed asbestos, highly resistant though this is in most applications, was desired and the firm have turned to the plastics material polytetrafluoroethylene or P.T.F.E., as it is usually called. The firm's name for the material is Klingerflon. We have dealt with this product on several occasions in recent years and our readers may recall that it is probably the most chemically inert plastics material so far available commercially for use over a temperature range of − 100 deg. C. to 250 deg. C. It has no known solvents or swelling agents and is only attacked by fluorine and molten alkali metals.

P.T.F.E. powder, which is the raw material from which finished products are made by pressing, sintering, and final pressing, is supplied by Imperial Chemical Industries, Limited, and as a result of their experience in producing packing sleeves for their cocks and also rings for their piston valves, Messrs. Klinger decided to enlarge their field of manufacture and are now producing, in addition, numerous gaskets, diaphragms, "chevron" rings for gland packings, O-rings for chemical seals, and sheets measuring 40 in. by 30 in. and from $\frac{1}{16}$ in. up to 1 in. thick. Thinner sheets, $\frac{1}{32}$ in. thick, are produced measuring 12 in. by 12 in.

Some of these items are seen in the accompanying illustration. A large cock packing sleeve with its longitudinal groove is shown on the extreme right. In contrast to P.T.F.E., compressed asbestos sleeves, as stated above, have a longitudinal ridge, the corresponding groove being in the body of the cock. The machined groove has been adopted for P.T.F.E. sleeves, in preference to a ridge, because the former is much easier to produce. The two circular ports of the sleeve are machined out. The sleeves have an outside diameter of 62 mm., an inside diameter of 50 mm., and a height of 67 mm. A smaller unmachined sleeve is seen in the centre, while in the foreground from left to right are an O-ring, two chevron rings for gland packings, a radio-valve holder, and two further chevron rings. In the background, on the right, is a diaphragm used in a rotary valve for various liquids and, leaning against it, three O-rings.

Quite recently, the firm have produced what they believe to be the largest P.T.F.E. gasket ever made in this country and perhaps in Europe. It has a length of 47¾ in., a width of 27 in. and a thickness of 0·125 in. The rectangular hole in the centre is 41¼ in. by 22¼ in. wide.

Another new development is the adoption, for certain applications, of the transparent plastic polytrifluorochloroethylene, made as Kel-F in the United States and as Hostaflon in Germany. This is used in level gauges intended for caustic fluids to protect the plate-glass window from attack by the fluid. The prevailing temperature, however, must not be higher than 100 deg. C. At present, the P.T.F.C.E., as it might be called, has to be imported but there is a possibility that it may be soon manufactured in this country.



Typical applications of P.T.F.E., the most chemically inert plastics material so far commercially available. It may be used over a temperature range of − 100 deg. C. to 250 deg. C., and its properties make it suitable for various insulating units, gland packings and chemical seals.

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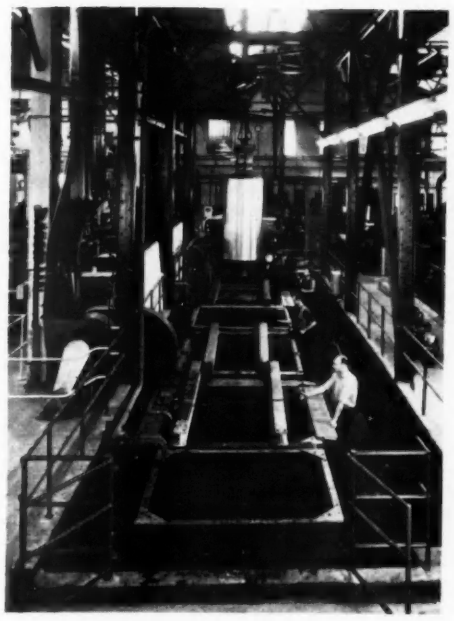
BURNING SLURRY

Experimental work on the burning of coal slurries, with the aim of releasing saleable coal, has been carried out by several companies, and in particular by Daniel Adamson and Company, Limited, Dukinfield, Cheshire, on one of their water-tube boilers which had a special stoker. The experimental boiler was designed for an output of 50,000 lb. of steam per hour and was fitted with a Martin mechanical stoker operating under automatic control. In the early experimental stages about 650 tons of slurry was burnt per week, resulting in the release of 450 tons of saleable coal per week.



A new heavy chromium-deposition plant installed at their Port Glasgow works by Fescol Ltd. The component being treated is a film drying drum used in the production of manganese sulphate monohydrate.

CHROMIUM-DEPOSITION PLANT FOR LARGE COMPONENTS

New plant for the electrochemical deposition of chromium, capable of accommodating components up to 15 ft. in length, 5 ft. in diameter and weighing up to 6 tons, has just been completed at the Port Glasgow works of Fescol Limited, 41 North-road, London, N.7.

The company, founded in 1920 by Mr. R. J. Fletcher and styled the Fletcher Electro Salvage Company, Limited, which name was eventually abbreviated to Fescol Limited, operate chromium-deposition plants at Port Glasgow, Huddersfield, and Brownhills (Staffordshire), as well as in London. The new plant has been designed specifically to meet a demand for the treatment of particularly large articles and as the London works are capable of handling nickel deposition on articles of up to six tons, it was necessary that the new chromium plant should have a similar capacity, as the company frequently carry out nickel deposition to build up heavily-worn components, before the final chromium coating is deposited.

The building in which the new plant has been installed has a height, to the eaves, of 20 ft. and it was at first thought that the treatment of articles having a length of 15 ft. would present difficulties owing to the fact that many types of hoist take up an appreciable portion of the head room. While the initial discussions were taking place, however, a Scandinavian low head-room hoist, the " Munck," was introduced into the United Kingdom by Taylor Stoker Company, Limited, Drummond-street, London, N.W.1. After investigation it was decided to install a 6 ton version of this hoist at Port Glasgow, as it required a space of only two feet from the underside of the beam to the hook when fully withdrawn, leaving 17 ft. between the hook and the floor. Two further advantages of the hoist were a micro-speed lift for " inching " and low-voltage push-button operation.

The hoist runway over the five tanks used for preparing components and for electrochemical deposition has been designed to carry a load of 10 tons, so that no structural alterations will be necessary if the capacity of the plant should be increased at a later date. As may be seen in the accompanying illustration which shows, undergoing treatment, a film drying drum used in the production of manganese sulphate monohydrate, the five tanks are housed in an asphalt-lined excavated pit with the tops of the tanks on a level with the factory floor. Space has been left between each tank for inspection and repair, and access for the operators is by means of a gallery running along the length of the pit. The depth of the pit brings the effluent from the tanks below the level of the existing drains so that a sump has had to be formed in the gully and acid-resistant pumps installed to transfer the effluent to the main drainage system.

A specially-designed cooling apparatus is employed to ensure the close control of the temperature in the deposition tanks and this enables a temperature of ± 1 deg. F. to be maintained. Electric current is supplied to the new plant through Westinghouse rectifiers and reverse switches. The building contractors for the installation were Baird Brothers (Port Glasgow), Limited, who also erected the hoist runway.

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DEVELOPMENTS AND USE OF GLASS FIBRES

Last year the world output of glass fibres totalled upwards of 500,000 tons and the number of persons employed in the industry aggregated about 25,000. At present glass fibres are employed in diameters ranging from 0·00012 inch to 0·000003 inch diameter, the former being used for air filters and the latter for the very lightest insulating medium which is fixed inside the skin of air liners to protect the passengers from cold and noise.

In the course of a lecture on " The Development and Use of Glass Fibres " which he delivered at the Royal Society of Arts, in London on February 13, Mr. A. Hudson Davies, managing director of Fibreglass, Limited, stated that glass wool which accounted for most of the tonnage output had fibres about 2 in. long but, by contrast, continuous-filament fibres were as much as ten miles in length. A glass fibre was made by pulling out viscous glass and the pull could be applied either directly or by the friction of a rapid stream of gas. In producing glass wool, now a standard material for sound absorption, the raw materials of glass, namely, sand, lime and soda, were ground finely and fed into a continuous furnace in which a temperature of 1,400 deg. C. was reached. When the finished glass reached the end of the furnace it ran into some twenty small platinum vessels or bushings about 12 in. by 9 in. by 6 in. in size, with, at the bottom, 32 tips, each carefully dimensioned and profiled. The bushings were heated by electric current and constituted the last correction point for temperature, which had to be very accurate to control the viscosity of the glass. From each tip a small stream of molten glass flowed by gravity and within an inch of its fall the stream was caught in a blast of superheated steam. By its whipping action the steam frayed out the stream of glass and dragged out a filament until it broke away from the stream and fell as a separate fibre into the collecting hood.

Binders of various kinds, including resin, stearine and bitumen, were sprayed on to the fibres as they fell. A mat of fibre collected below on a conveyor and was carried away, first through curing ovens, to dry and set the binding agents, and then away to trimmers and guillotines which shaped the final product.

Most resins had good strength in compression, but they were poor in tension, and rather brittle. When glass fibres were united with a resin they performed the task which steel did in reinforced concrete. Glass-reinforced plastics were extremely strong and also extremely light. Among present uses of these products, corrugated translucent roof panels took about 30 per cent., of the market; boats, from dinghies to cruisers, about 10 per cent.; military uses and aircraft 30 per cent.; and commercial vehicles, including public transport, about 12 per cent.

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COMBATING RUST ON THE FARM

Reference was made to the ravages of rust and its limiting effect on the life of farm machinery in general and on that of the fertiliser distributor in particular, at a recent works conference of E. H. Bentall and Company, Limited, Maldon, Essex. It was pointed out that the fertiliser distributor must withstand the corrosive effect of superphosphates, sulphate of ammonia, muriate (chloride) of potash and other products. Corrosion tests on mild steels and high-grade alloy steels carried out by the firm have shown that these are all liable to attack by the three artificial fertilisers mentioned above, and, so far, it has not been possible to produce a ferrous alloy that is entirely immune. The silicon-chromium valve steel En 52 tested was " slightly rusted," the high nickel-chromium-tungsten valve steel En 54, and the hardened and tempered chromium-nickel-silicon valve steel En 59, were " very slightly rusted," and the austenitic chromium-nickel steel En 58J was " very minutely pitted."

The firm believe that the answer is a lasting protective coating and they hope soon to arrive at the solution. Cadmium and chromium plating on mild steel do not seem to have been at all successful, but a zinc electroplated coating was only " slightly discoloured " after the corrosion test. Encouraging results were given by other plating processes the investigation of which is still proceeding.

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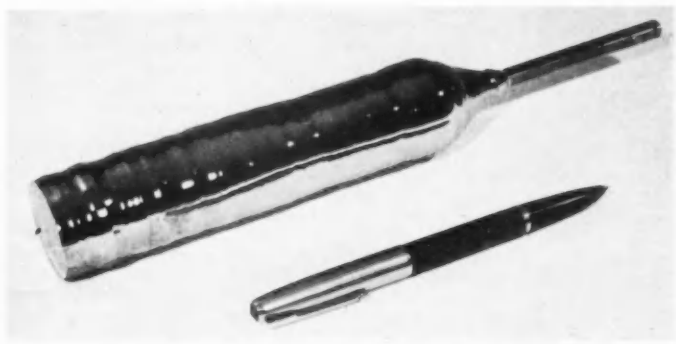
LARGEST GERMANIUM CRYSTAL

One of the world's largest single crystals of germanium has been grown recently at the research laboratory of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. The impurity content was controlled to less than one part in 20 million and the value of the 1·2 kilogram crystal is put at £650. It was produced by a process involving the gradual withdrawal, over a period of six hours, of a rotating seed crystal from a pool of molten germanium.

Single crystals are used in solid-state devices such as transistors, where accurate control of impurities is essential. Since the single crystal is cut into very many small wafers, less material is wasted at the side and ends if the crystal is large.



A single crystal of germanium grown in 6 hours and weighing 1·2 kilograms.

Book Reviews

FERTILE GROUND

The Draining of the Fens. By H. C. DARBY. Second edition. *Cambridge University Press, Bentley House, 200 Euston-road, London, N.W.1.* (35*s.*)

The first edition of Dr. Darby's book so quickly established itself as a valuable survey of this eastern area of England that a reviewer of the second edition may be tempted to regard the original material as something " to be taken as read." That would perhaps be justified in the sense that the book has in fact been read, and with lively appreciation, by geographers, economists, engineers and many other people with wide interests. But, as the preface to the new edition explains, the only significant change is that the final chapter has been enlarged to include some reference to events since 1940, which suggests that the present work must be considered as a whole.

These quite recent events themselves provoke the question: was there not just a possibility of misunderstanding in keeping the title " Epilogue " for the last chapter ? New readers might imagine that the word implies the conclusion of fen drainage rather than the end of the book; whereas, on the contrary, work on the ground is going forward as energetically as ever. As the author points out, the water control works now in course of execution there rival in scale any earlier ones. Three hundred years ago the men who initiated comprehensive drainage projects called themselves " adventurers ": their successors to-day no longer use that title but their spirit has not changed. No longer, though, can they be sustained by the hope that a single resounding victory will banish all their cares. The engineer has created new problems, or intensified old ones, nearly as fast as he has solved others. The more effectively the peat land is drained, the more rapidly it dries and shrinks, the quicker the land surface level subsides, and the greater the need for augmented pumping capacity.

These interlinked sequences create problems for the cultivator, too. In the face of changing conditions, he has had to be just as resourceful as the engineer. Having tried wheat and potatoes, he may then have turned to small fruit, market garden crops, and flowers; and while, in a dry season, his tulips are approaching a perfection hitherto only to be found overseas, the wind may erode black dust from the land, carry it on to the blooms and thereby ruin them for the market.

Although *The Draining of the Fens* was not written expressly for engineers, its author understands their outlook, and he may therefore not take it amiss if we wonder whether " draining " was the best word to choose just now. Why not " reclamation " ? It is true that on general grounds the term may be thought to have too wide a significance: for example, the United States Bureau of Reclamation concerns itself with irrigation rather than with drainage. But we should not be too scrupulous in our efforts to reclaim from the wastes of ignorance and indifference the greatest possible share of public interest in what engineers are doing. And public interest is a very sensitive plant: it is liable to shrivel up at the slightest breath of what it regards as dull or disagreeable. Fens are flat, therefore fens are dull: drains, if not actually nasty, may be slightly comic, a subject for facetious comments. But reclamation need not inspire revulsion, for it may embrace lost souls and erring youth as well as provinces.

No matter how Professor Darby's book is entitled, it unfolds a deeply interesting story. It describes how, in little more than three centuries, low-lying areas of unproductive land in East Anglia have been transformed into one of the most fertile districts in Great Britain. In this narrative, historical, administrative and legal strands are interwoven with commentaries on engineering technique. When the volume of drainage water to be lifted threatened to overpower the wind-driven scoop-wheels, the steam engine came to the rescue, to be succeeded in turn by the rotodynamic pump, the heavy-oil engine and the electric motor. Because of these piecemeal developments, the fenland drainage system as it exists to-day is necessarily highly complex; but the carefully-chosen maps, ancient and modern, the diagrams and photographs give as clear an impression as anyone could hope to gain. As Dr. Darby wrote most of the book at King's College, Cambridge, and as he is now Professor of Geography at University College, London, we can be assured that a scholarly perspective is always maintained. With his help, we can interpret our own memories of the great storm surge of 1953 and the floods of 1947 so as to share the feelings of the local inhabitants who faced worse disasters in earlier years.

It is a publisher's note that serves to remind us happily of interchanges of various kinds between the low countries on both sides of the North Sea. Cornelius Vermuyden, the Hollander who ended his life as an English knight, carried out the first major fenland drainage project in the seventeenth century. By devising the revolving-cap windmill, dutch millwrights notably enhanced the effectiveness of wind-driven lifting machines. In the nineteenth century, vast pumping engines built in England helped to reclaim new polders in Holland. And now, in the second half of the twentieth century, a Netherlands printing house has prepared this admirable second edition of Dr. Darby's book.

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NOT FOR THE EXPERT

Applications of Instrumentation and Automatic Control. *Federation of British Industries, 21 Tothill-street, London, S.W.1.* (5*s.*)

This clear and useful statement of the possibilities and principles of measurement and control of industrial processes is aimed at the non-specialist works manager or engineer, rather than the expert, and it should be useful in stimulating more efficient operation of plant. In view of current fuel difficulties it is no doubt appropriate that half this pamphlet of 68 pages should be devoted to the control of steam generating plant; the balance being concerned with such examples as water supply and sewage purification, the chemical and metallurgical industries and the oil industry.

While the function of automatic control is described as that of releasing labour, the increased consistency of final product and saving in raw materials and power are also stressed. Many control engineers would, in fact, consider the latter the most important of the results of improved instrumentation and automatic operation.

Simple descriptions are given of the principles of instruments for measuring pressure, water level, draught, temperature, flow, flue gas analysis and smoke density and, in the second part, general descriptions of the three basic types of measuring instruments: those responsive, respectively, to a displacement, a pressure or an electrical input. The principles of the popular pneumatic transmitters whereby a force, in the form of a weight, pressure or differential pressure, is converted into a proportionate air pressure within a standard range, are fully described, as well as those of electrical measuring instruments, and examples are given of their application.

In the section on automatic control it is stressed that modern devices have been developed to deal with hitherto insoluble problems and not to replace simple " self-actuated " controllers. A simple illustration is the maintenance of constant liquid level in a tank under conditions of variable draw-off, where an advanced form of controller would be needed, in contrast with the simple float-operated valve which alone is necessary when all that is required is to ensure that the tank neither drains nor overflows. Brief descriptions are given of the various controlling units and their combinations which are available, and by means of which practically any desired combination of functions can be performed without human intervention following signals which transmit the sum, difference, ratio or average of similar or different physical variables. Surprisingly, there is no reference to the growing part played by the electronic computer in these processes.

* * *

USING TRANSISTORS

Transistors in Radio and Television. By MILTON S. KIVER. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (5 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (37*s.* 6*d.*)

This book is stated to be " a completely descriptive non-mathematical book for the radio and television technician and all other technical workers in the electronics field who need a working knowledge of transistor circuits. Only a knowledge of basic electronics is required for complete comprehension." There is a great need for a book fulfilling these aims, but it must contain sound design principles and accurate information if the reader is not to be misled.

The first three chapters deal with " electron theory " and its application to point-contact and junction transistors, and apart from several errors make quite useful reading. The next six chapters deal mainly with amplifiers, oscillators and complete receiver circuits. Although a succession of circuits is presented, with descriptions of their operation, there is no explanation of the underlying design principles involved. Unfortunately many of these circuits are based on faulty design principles, and a reader having less knowledge of transistor circuits than the author would be completely misled.

Some examples of incorrect or misleading statements are that a germanium junction diode biased in the forward direction has a voltage of " 4 or 5 volts across it," that the collector leakage current, i_{co}, of a point contact transistor is " a few microamps," and that a typical grounded-collector amplifying stage has " a voltage gain of 0·3 " and " can pass signals in either direction, being a two-way amplifier." Many of the amplifiers would not operate as described in the book unless the transistor had a low current gain, α'. Higher values of α' would bias the amplifier into a non-linear region and destroy the gain: a fault which would have been self-evident if correct design principles had been given.

The final chapter describes several experiments for the reader to perform himself, but here again many of the circuits would not operate as described. If the frustrated experimenter suspects the transistor, and tests it in the special test circuit described by the author, he may well conclude that a good transistor is faulty. In fact this test circuit tends to accept faulty transistors and reject good ones. Another test circuit, recommended by the author for displaying the characteristics of point-contact transistors, would not do so but would almost certainly destroy the transistor. The overall impression is that although the author may be familiar with radio and television he is not in close touch with transistor circuit design.

It is hoped that a newcomer to transistors, who may have read this book, will not dismiss them as being perplexing and unreliable as a result. Correctly designed transistor circuits are simple, elegant, and very reliable, and compare favourably in almost all respects with thermionic valve circuits. The ease and rapidity with which

a transistor circuit can be wired up on a simple tag board is most marked compared with the work required to prepare the chassis and connect the heaters for a thermionic valve circuit. Other advantages which accrue from the use of transistors are the safety and convenience of low voltage supplies, high operating efficiency, and the absence of generated heat and warm-up time.

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NEW BOOKS

Analog Computer Techniques. By CLARENCE L. JOHNSON. *McGraw-Hill Book Company, Incorporated*, 330 *West 42nd-street, New York* 36, *N.Y., U.S.A.* (6 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (45*s.*)

The book contains the material used in computer courses for advanced undergraduate and graduate students at the U.S.A.F. Institute of Technology, Ohio. Following the introductory and general material on electronic analogue computers, the volume deals with specific techniques for the solution of difficult or unusual problems. Special emphasis is given to function-generating techniques and to the synthesis and performance of computers for analysing servo mechanisms.

Phase Diagrams in Metallurgy—Their Development and Application. By FREDERICK N. RHINES. *McGraw-Hill Book Company, Incorporated*, 330 *West 42nd-street, New York* 36, *N.Y., U.S.A.* (12 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (90*s.*)

The aim of the author of this book has been to present his subject in a manner which can be grasped by students, whose primary interest is in the application of phase diagrams to metallurgical problems. Metallurgical examples are used in all the illustrations and the presentation is designed to lead the reader into the subject gradually. Phase diagrams are approached from the point of view of their structure and use rather than their determination. The chapter on quaternary or multi-component systems is particularly complete and an attempt is made in the chapter on pressure-temperature diagrams to condense this diffuse subject into its essentials.

Handbook of Semiconductor Electronics. Edited by LLOYD P. HUNTER. *McGraw-Hill Book Company, Incorporated*, 330 *West 42nd-street, New York* 36, *N.Y., U.S.A.* (12 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (90*s.*)

The manual covers the physics, technology, and circuit applications transistors, diodes, and photocells. Each of the 20 sections is followed by a list of references and in addition there is a 68 page bibliography containing some 2,000 entries. Thirteen contributors provide a wealth of detail on graphical analysis of non-linear circuits, computers, oscillators, amplifiers, matrix algebra, crystal growth, and conduction in solids.

Handbuch der Kältetechnik. Vol. 4: Die Kältemittel. Edited by RUDOLF PLANK. *Springer-Verlag, Reichpietschufer* 20, *Berlin* W.35, *Germany*. (78 *D.M.*)

Three writers contribute to this fourth volume in a series of twelve, covering the entire field of refrigeration. It is intended for refrigeration engineers, physicists and chemists, and is devoted exclusively to the refrigerants used. The behaviour of refrigerants in the presence of other materials, lubricants and impurities is given special attention, as it is considered that this aspect has not been adequately dealt with in the past. Then the refrigerants are examined in greater detail individually, more attention being paid to the chief mediums in current use than to those for special purposes. A few refrigerants are included which have not yet reached the stage of practical importance but which may do so in the future owing to their characteristics. The text is fully supported by diagrams, tables and reference data.

PROJECT ENGINEERS SEE THE WHOLE JOB THROUGH

*By Desmond B. O'Shea,** M.A. (CANTAB.), M.I.C.E., A.M.I.MECH.E.

The present era of industrial expansion, and the need to construct factories and similar complex engineering works on a well planned basis, have given rise to a call for experienced engineers who are able to co-ordinate the planning and construction of the whole scheme from start to finish. Such engineers—we call them "project engineers"—must have a wide experience of engineering practice in the three main branches of civil, mechanical, and electrical engineering and, in particular, a thorough knowledge of contract procedure and site organisation. They must be able to take responsibility for the general design and planning of a project, and the co-ordination of the various specialist sections. Frequently it is necessary for them to be responsible for the erection of large chemical plant.

Project engineers must be responsible for an effective liaison between clients, consulting engineers, manufacturers of plant, contractors and also the resident staff engaged on construction. Their work demands not only a full knowledge of the technical side of planning and construction, but also a flair for ironing out the constant difficulties and even potential disputes which are sure to arise between the various parties interested in a major financial undertaking. The rapid analysis and solution of a new problem, during the dynamic period of construction, is no easy matter but, in many cases, it rises to a commercial "must" if plant is not to be stopped working and additional expense is to be avoided. It is up to the project engineer to cope with these matters. Organising ability and drive are, therefore, essential but the latter must be tempered with tact and skill if friction is to be avoided and steady progress maintained.

It may be said that it should be sufficient to entrust the scheme to a firm of consulting engineers. Often however, the specialised requirements of an industry will necessitate frequent consultations and too much of the chief engineer's time would be taken up, more than he could spare. When two or more major schemes are undertaken at the same time, it becomes essential that one experienced and senior engineer should devote his time to projects only.

* Project engineer, W. & H. M. Goulding Ltd.

CONSULTING ENGINEER

The project engineer may be engaged by the consulting engineers, as part of their staff, or he may be engaged by the clients. He may feel happier if he is engaged by the clients and there is a natural tendency also for the clients to favour this procedure, as they are inclined to feel that their interests will be better served and that they are in a better position to achieve their own way when differences and difficulties arise. The engineer himself may consider it advantageous to be on the client's staff as it gives him a better opportunity to consult fully with the client's engineers, and to attend the firm's technical and business meetings.

Some project engineers, however, would prefer to be on the consulting engineers' staff or at any rate on the same basis as resident staff, namely, paid by the client but responsible to the consulting engineers. A project engineer may feel, as his ultimate aim is to "contract and construct," that in dealing with the consulting engineers he is with personnel who speak the same language as he does. In addition, in all such schemes, the consulting engineers are usually the pivot for the whole scheme as far as actual construction is concerned. A further point is that a firm, even a large organisation, cannot always afford to promote new projects indefinitely and consequently the term of engagement may be limited. On the other hand if he is employed by the consulting engineers there is, perhaps, a better opportunity of further engagement for the project engineer as further schemes arise in a wider field of industrial activity.

Now turning to the actual work involved: the early stages will consist of planning and design. It is essential that the project engineer should be in the picture from the very beginning. In these days it is quite usual to form the various specialists, i.e., the various technical branches and the commercial and management interests, into a committee. The result of this committee's work should be the production, by the project engineer, of a completed report with sufficient preliminary drawings and data to enable the consulting engineers and others concerned to prepare and issue tender documents and drawings. At this stage the report, which will contain—in appendices—the recommendations of specialists, will require to be studied by the chief engineer before it is submitted for discussion to the board of directors. Financial and other commercial considerations may cause considerable alteration and prolonged discussion before the final scheme is approved. In many cases part only is approved for immediate construction, the remainder being withheld for further consideration on account of financial or other reasons.

LIAISON WORK

The amended and approved scheme should be handed to the consulting engineers so that they can prepare the tender documents and proceed with the preparation of the final contract documents together with specifications and working drawings for that part of the scheme which is to be undertaken by civil engineering or building contractors. Meanwhile, contracts will be prepared for such special items as chemical plant, machinery such as processing plant and conveyors, and also electrical distribution transformers, etc. It will be necessary for the project engineer to hold a watching brief and to be kept informed of all developments relating to these matters so that the whole may be welded by him into a well programmed and workable scheme. Depending on the size and extent of the contract, resident staff will be required to supervise the contract for the client. In works which are in the hands of the consulting engineers, the resident staff is supervised by them, but in the case of the mechanical and electrical contracts and the erection of chemical plant the "engineer" as quoted in the contract will be the project engineer, and he will be responsible to the clients for the supervision of any of the clients' resident staff employed in supervising such work. He will also be responsible for any liaison between the various supervisory organisations on the site.

It will be seen that there is considerable advantage gained if the project engineer is a member of the consulting engineer's staff as many of the complications of supervision are then simplified and unified under one control. Also, in these circumstances, the client has only one party to deal with, i.e., the consulting engineers. Whatever arrangement is made it will always be necessary for the project engineer to work in close co-operation with the clients' specialist engineers on the matter of plant installation as numerous minor alterations, additions and difficulties and points of construction requiring discussion are sure to arise during construction. Even if the planning and contract negotiations have been completed in the most perfect manner, success cannot be fully achieved without a smooth and harmonious atmosphere on the actual construction. It is impossible to over-emphasise this point, since any interference with the resident or contractors' staff which causes a serious upset will inevitably show itself on the progress charts.

The keynote of success is mutual confidence and respect between the project engineer, the resident staff, the contractor and the men who are doing the job. All parties engaged on the construction must feel that the project engineer knows his job and knows how to do it, and that his experience and knowledge enable him to appreciate, and use in a sensible manner, the skill of every man from the senior resident engineer to the youngest apprentice.

THICKNESS OF HIGH-TEMPERATURE STEAM PIPES

By J. S. Blair, D.SC., M.I.MECH.E.*

It may be recalled that in our issue of February 18, 1955 (vol. 179), on page 205, we published an article by Dr. Blair having the above title. In this, arguments were developed with regard to the formulae to be used for pipes under creep conditions, and the stresses for 2¼ per cent. chromium 1 per cent. molybdenum steel. It is now three years since the data for that article were collected, and during that time a considerable amount of work has been done, particularly by Stewarts and Lloyds Research Department at Corby on the creep properties of 2¼ per cent. chromium steel. As a result, some reconsideration should now be given to the proposals then put forward. The portion of the article which dealt with the theoretical treatment of the stresses remains unaltered, but the formulae and design stresses to be used in practice require further consideration.

ELASTIC CONDITIONS

Choice of Formulae.—It will be remembered that it was argued that where creep conditions do not apply, the formula to be used for steam pipes should be the outside-diameter formula (Barlow's), namely:

$$P = \frac{2St}{D},$$

where P = internal pressure, S = stress, t = thickness, D = outside diameter. This predicts to a sufficient degree of accuracy the relationship between the pressure and the *stress* occurring in a pipe.

The majority of specifications lay down the design *stress* often as a fraction $\left(\frac{1}{F}\right)$ of the tensile strength, where F is the factor of safety. In other words, the design pressure produces a stress equal to the tensile strength divided by F. This is, however, not the same thing as saying that the design pressure can be multiplied by F to obtain the bursting pressure. In fact bursting will not occur until the pressure applied is appreciably more than F times the design pressure.

On the other hand, the factor of safety F in such a case is a somewhat fictitious one in that pipes are generally seriously damaged if the stress is allowed to exceed the yield point, so that in fact, little more than half the apparent factor of safety is available before such a condition occurs.

It might be argued, therefore, that a better basis is to use the yield point of the material for this relatively low temperature condition, and to use a factor of safety of say, 1½, based on the yield stress (or 0·2 per cent. proof stress). In such a case again the outside-diameter formula is the best one to apply, and it is immediately possible to obtain the true factor of safety on yield by dividing the yield stress by the stress obtained from the outside-diameter formula.

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There are, however, a number of objections to the use of the yield stress as a basis, particularly since it need not bear a constant relation to the tensile strength, and a material with an artificially raised yield point may indeed be less safe than a more normal one. Pipe design in British Standards is seldom based on the yield point, the tensile strength being considered a better, more uniform, property of the material, and the factor of safety on tensile strength being adjusted to maintain the design stress comfortably below the lowest yield stress likely to be encountered.

Those who advocate the use of the mean-diameter formula, namely, $P = \frac{2St}{(D - t)}$, point out that it accurately predicts the bursting pressure of a pipe when used in conjunction with the tensile strength of the material. Thus the design pressure can be taken as the bursting pressure divided by F, though it must be remembered that under these conditions, the *design stress* will be *greater* than the tensile strength divided by F. It will not be safe, therefore, to apply more than the design pressure multiplied by half of F without danger of yielding the pipe.

It may well depend upon the purpose to which the pipe is to be put as to which is the better of the two bases, but it should be clearly appreciated that if the outside-diameter formula is used, then the design is being based on a specific *stress*, while if the mean-diameter formula is being used, the design *pressure* is an agreed fraction of the bursting pressure. There would appear to be no justification for using, for example, the mean-diameter formula under the impression that it will predict the elastic stress in the pipe.

The above may be summarised by saying that where creep does not occur, if the bursting pressure is to be the criterion of design, the mean-diameter formula should be used. This is not, however, the customary method of design favoured by British Standards in which the design of pipes is usually based on a design *stress* which is of course well below the yield point, and therefore, elastic conditions prevail. Since this *stress* must not be exceeded, Barlow's formula should be used.

Stresses.—In practice, however, as far as high-temperature steam pipes are concerned, the stresses which occur at the lower temperatures due to internal pressure are relatively unimportant since it is the creep conditions, at working temperatures and pressures, which determine the pipe thickness. The majority, if not all, of the stresses (other than those due to internal pressure) occurring in a steam pipe, when cold, disappear wholly or to a large extent when the pipe warms up, so that the factor of safety necessary for the cold stresses, such as bending, etc., can be very much less than would be necessary if the pipe were to be working at these temperatures.

It is suggested that for such transient conditions the permissible stress should be 40 per cent. of the tensile strength of the material at room temperature (i.e., a factor of safety of 2½). Such a stress will still be appreciably below the lowest yield stress likely to be encountered.

Where special steels are used for high temperature conditions, it is the permissible stress at design temperature which governs the thickness to be chosen for the pipe, and no pressure stresses need be calculated at lower temperatures, though as mentioned above the cold pull stresses have to be taken into account. For mild steel, however, suitable design stresses must be established for the whole range from low to high temperatures, and only at the extreme upper end of the range, say from 850 deg. to 900 deg. F., if even there, need creep conditions be taken into account. It is customary to allow the pressure stress at room temperature to be one quarter of the tensile strength up to some quite high value such as 500 deg. F., at which point, the permissible stress usually decreases so as eventually to meet the appropriate creep stresses at about 850 deg. F., care being taken throughout this range to see that a reasonable margin is maintained between the design stress and the yield stress at the design temperature. This yield stress is usually taken as the 0·2 per cent. proof stress. It is suggested that this room-temperature stress equal to a quarter of the tensile strength is unnecessarily low, and that it might well be one-third. This will still be appreciably below the lowest yield stress likely to arise, but it may now be necessary to start reducing this stress at temperatures above, say 100 deg. F. to ensure that it is not more than, for example, two-thirds of the 0·2 per cent. proof stress at the design temperature. Since this article is concerned primarily with low-alloy steel pipes for high-temperature service, it is not proposed here to enter into this matter in any more detail, but merely to suggest a basis for such design.

CREEP CONDITIONS

Formula.—As regards the formula to be used

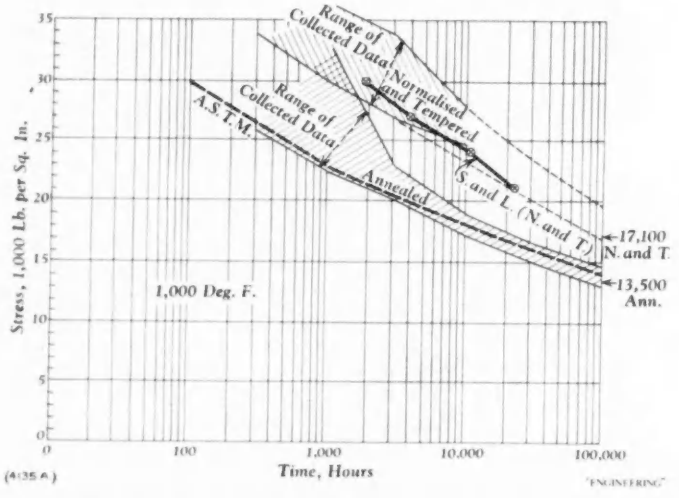


Fig. 1 Creep rupture conditions of 2¼ per cent. chromium 1 per cent. molybdenum steel at a temperature of 1,000 deg. F.

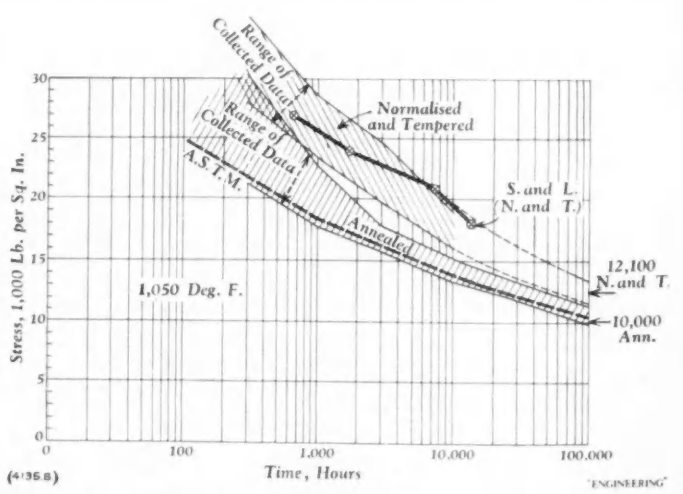


Fig. 2 Creep rupture conditions of 2¼ per cent. chromium 1 per cent. molybdenum steel at a temperature of 1,050 deg. F.

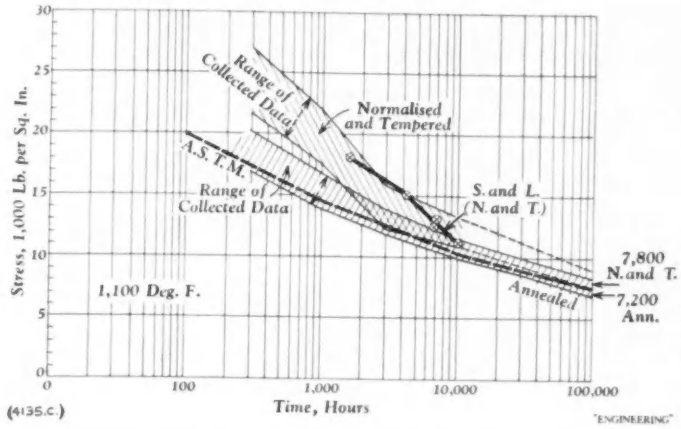


Fig. 3 (left) Creep rupture conditions of 2¼ per cent. chromium 1 per cent. molybdenum steel at a temperature of 1,100 deg. F.

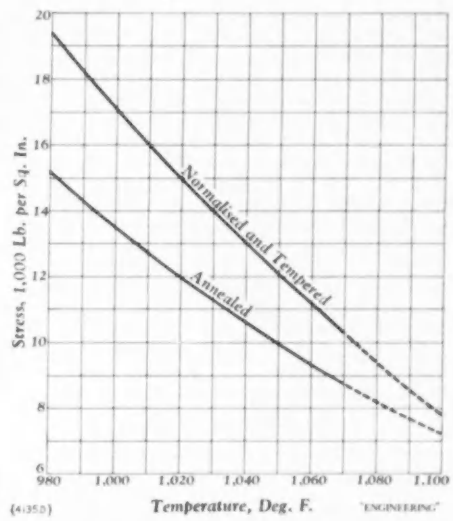


Fig. 4 (right) Creep rupture of 2¼ per cent. chromium 1 per cent. molybdenum steel in 100,000 hours.

under creep conditions, the earlier article put forward reasons for proposing the bore formula, $P = \frac{2St}{d}$ where d = bore, and these reasons still apply.

It should be noted incidentally, that the bore formula will predict the pressure under which the pipe will burst under creep conditions, and it might, therefore, be logical to suggest that the mean-diameter formula should be used for conditions under which creep does not apply, since it, also, predicts the bursting pressure.

Stresses for 2¼ per cent. Chromium 1 per cent. Molybdenum Steel.—When the previous article was written, there were considerably fewer data available for 2¼ per cent. chromium 1 per cent. molybdenum steel than there are now. For example, Stewarts and Lloyds, Limited, alone have made many creep tests on this material, in some cases up to 25,000 hours' duration, and other investigators have also supplied many data. Moreover, the data previously available were almost exclusively concerned with 2¼ per cent. chromium steel in the annealed condition as is commonly used in America. Although it was known at the time when the earlier article was written that, in the normalised and tempered condition, this steel had better creep properties, there was not then sufficient information to warrant serious departure from the American stress basis. Now, however, there is evidence to allow use to be made of these improved characteristics. More also is known about annealed material. Figs. 1, 2, and 3 show these data, all of which refer to the creep rupture condition which, as previously pointed out, is the important one where the design of pipes is concerned.

It will be seen that the information is given for three temperatures, namely, 1,000 deg. F., 1,050 deg. F. and 1,100 deg. F., though the highest of these temperatures is greater than the maximum of 1,070 deg. F. to which 2¼ per cent. chromium steel steam pipes should be subjected.

Dealing first with the annealed material, the latest extrapolated values at 100,000 hours are very similar to those obtainable from the A.S.T.M. line, though, in general, the minimum values obtained lie slightly below this line. Nevertheless, even these minimum values are higher than the values which were put forward in the previous article of February 18, 1955, and it is suggested, therefore, that a suitable basis might be the values shown in Fig. 4 and Table I at the foot of this page.

As regards the normalised and tempered material, at 1,000 deg. F. the permissible stresses are some 30 per cent. higher than for the annealed material. Fig. 2, however, shows that as the temperature rises to 1,050 deg. F., this difference becomes less, being only some 20 per cent. at this temperature, while at 1,100 deg. F., the two bands overlap, though the normalised and tempered condition is still slightly better than the annealed condition. It is evident, therefore, as is to be expected on metallurgical grounds, that the higher the temperature and the longer it is applied, the less difference there will be between the two conditions. It does, however, appear that there is a genuine improvement in results at temperatures up to 1,100 deg. F. arising from the use of normalised and tempered material rather than annealed material.

If design stresses continue to be based on the annealed condition, there is obviously little point in going to the additional trouble of normalising and tempering, except to provide an unnecessarily high hidden factor of safety. It would be much more reasonable to advocate the use of higher stresses for the normalised and tempered material, which incidentally is in a better condition metallurgically. This, of course, means two different sets of design stresses depending upon the condition of the material, and these are shown in Fig. 6 and Table I.

Required Life.—In the earlier article, it was suggested that a realistic basis for the life of a power station might be 200,000 hours. Considering that the modern high pressure and temperature power station is almost invariably a two-shift station, it would seem that 100,000 hours, which on this basis, including shut-downs, represents about 18 years in the life of the station, is an adequate figure on which to base the creep rupture stress. Departures from this figure in practice are not likely to be great, and as will be seen later, are adequately covered by the factor of safety which is normally allowed on the creep rupture stresses.

TABLE I *Proposed Stresses for 2¼ per cent. Chromium 1 per cent. Molybdenum Steel*

Temperature	Creep Rupture Stress for 100,000 Hours		Design Stress	
	Annealed	Normalised and Tempered	Annealed	Normalised and Tempered
Deg. F.	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.	Lb. per sq. in.
Cold pull	—	—	40 per cent. of minimum tensile strength	
950	18,300	23,400	12,200	15,600
960	17,200	22,000	11,470	14,670
970	16,200	20,700	10,800	13,800
980	15,200	19,400	10,130	12,930
990	14,300	18,200	9,530	12,170
1,000	13,500	17,100	9,000	11,400
1,010	12,700	16,000	8,470	10,670
1,020	12,000	15,000	8,000	10,000
1,030	11,300	14,000	7,530	9,330
1,040	10,600	13,000	7,070	8,670
1,050	10,000	12,100	6,670	8,070
1,060	9,400	11,200	6,270	7,470
1,070	8,800	10,300	5,870	6,870
1,080	8,200	9,400	—	—
1,090	7,700	8,600	—	—
1,100	7,200	7,800	—	—

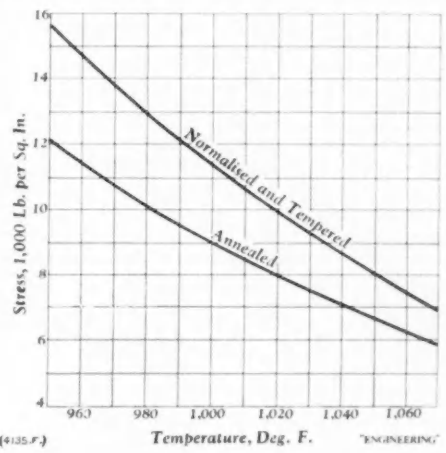


Fig. 6 Design stresses for 2¼ per cent. chromium 1 per cent. molybdenum steel.

DESIGN BASIS

As previously mentioned, when alloy steels are used for high-temperature work, it is not necessary to calculate the thickness of the pipes for pressure stresses other than those at the temperatures at which they have to work. Thus, the temperature range for 2¼ per cent. chromium-steel steam pipes, for example, is limited to about 950 deg. to 1,070 deg. F.

It is customary to show a stress curve for all temperatures for such steel, and in American practice in the middle range of temperature, this curve is based on some fraction of the yield strength (0·2 per cent. proof stress) at the appropriate temperature. Since no calculations are made in this range, this seems a somewhat unnecessary procedure, and all that is needed is to make sure that, at the lowest temperature

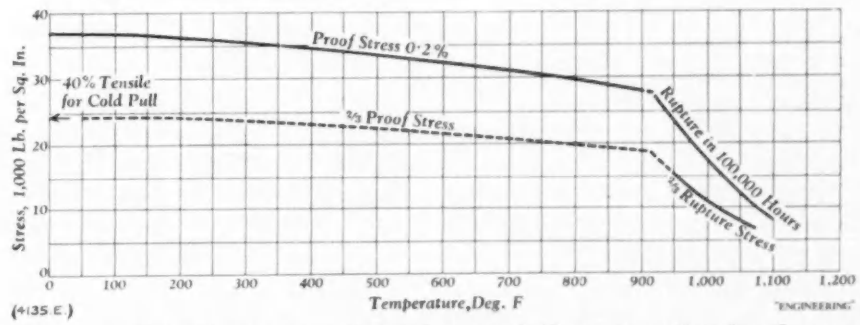


Fig. 5 Stress relationships for normalised and tempered 2¼ per cent. chromium 1 per cent. molybdenum steel.

for which the material is likely to be used, the stress based on creep rupture, does not exceed an agreed fraction, usually two-thirds, of the 0·2 per cent. proof stress. Fig. 5 shows such a curve in the case of the normalised and tempered 2¼ per cent. chromium steel, from which it will be seen that the creep-rupture curve and the proof-stress curve in fact cross one another at 920 deg. F., and above this temperature only the creep-rupture curve need be considered. At the other end of the temperature range, namely, room temperature, the only stress under consideration is that to be allowed for cold pull, which as previously suggested can be taken as 40 per cent. of the tensile strength. Fig. 5 shows that this is still well below the proof-stress curve.

It is suggested that the stress value to be used in calculations of pipe thickness within the creep range should be two-thirds of the stress to cause rupture in 100,000 hours. These values are shown in Table I and Fig. 5, and on an enlarged scale in Fig. 6 for both normalised and tempered and for annealed material.

It may at first be thought that a factor of safety of 1½ on the rupture condition is somewhat small, but it must be appreciated that this means in fact that if 100,000 hours be taken to represent 18 years in the life of a power station, such a station will last for 250 years at two-thirds of this stress, and even allowing for a possible error of 20 per cent. in the true strength of the material, i.e., only 80 per cent. of the rupture line shown in Fig. 4, the life of the station would still be 50 years. Indeed, it may well be that an even higher fraction of the rupture stress could be considered as a suitable basis for design. In the present state of our knowledge, however, and bearing in mind the values used in other countries, it would seem that the proposed value of two-thirds may be a suitable basis to be adopted at present.

It should be remembered that the pipe thickness is generally greater than the minimum required, and there is also a belief that transverse creep in a pipe in service does not take place as rapidly as in a tensile-creep test piece at the same stress. So that here again there are hidden factors of safety.

Added Constant.—It has been customary in British practice to add to the thickness calculated by the direct application of the design formula a constant (frequently 0·04 in.) to allow for wastage. There has always been considerable doubt as to what this added constant really covers, since corrosion is not present at these temperatures, nor does there appear to be any other form of wastage which should be allowed for, other than scaling which may be negligible.

In the previous article it was suggested that this 0·04 in. constant might be retained, but there now seems to be a general view that scaling is unimportant at least up to the maximum temperature for which it is considered 2¼ per cent. chromium steel should be used. It is, therefore, suggested that this constant might be dropped altogether, so that, for creep conditions, the bore formula should be used utilising the minimum thickness. Any reduction in the life of the pipework arising from scaling is amply covered by the greatly extended life previously mentioned as arising from the factor of safety used on the creep rupture stresses.

CONCLUSIONS

The above modifications to the original article of February 18, 1955, are chiefly concerned with the use of 2¼ per cent. chromium 1 per cent. molybdenum steel, and may be summarised as follows. At temperatures at which creep does not take place, it is suggested that there is need for a definite decision as to whether design should be based on bursting conditions or elastic conditions.

Since factors of safety depend so much upon the service to which the pipe is put, a convenient basis is first to determine the stress which will cause failure, either immediately (yield), or at the end of the specified life of the pipework (creep rupture), and then by the use of the appropriate factor of safety take some fraction of this stress for design purposes. Since alloy-steel pipework does not need to be designed for low-temperature conditions, it is only necessary to know the creep rupture strength for the working temperature, and the room-temperature tensile strength for cold-pull calculations. In the case of mild steel, however, which may be used at any temperature up to the maximum permissible, it is probably best to consider that failure will occur if the 0·2 per cent. proof stress is exceeded unless creep rupture stresses are lower than this proof stress.

Higher design stresses are put forward, as is shown in Table I, to take advantage of the increased strength of 2¼ per cent. chromium material in the normalised and tempered condition. The additional thickness of 0·04 in. customarily added when designing steam pipes is considered to be unnecessary, any scaling or other forms of surface deterioration being more than covered by any reasonable factor of safety.

The author is indebted to Messrs. Stewarts and Lloyds, Limited, for permission to publish this article.

THE ELAND CONVAIR CONVERSION

Piston Engines Replaced by Turbo-Propellers

America's domestic airline operators are responding to the recent decision by Trans Canada Airlines to base their home fleets on propeller-turbine propulsion by an increasing and active interest in the proposals by D. Napier and Son, Limited, for converting existing piston-engine airliners to turbo-propelled machines. The 3,500 h.p. Napier Eland is eminently suitable for re-engining airliners such as the Convair 340 and 440, the Douglas DC6B, and the Constellation 749. On world airliners to-day there are 285 Convairs, 321 DC6B's and 325 Constellation 749 airliners, so the possible market for Eland conversion—quite apart from new projects—is substantial.

The most outstanding gains are to be found in the Convair 340 converted to Elands, because the take-off power (2,400 h.p.) of the existing Pratt & Whitney R-2800-CB16 piston engines of this aircraft is insufficient to allow it to operate at the maximum design weight. For some months now Napier have been flying their own Eland Convair conversion (Fig. 1), and an account of the engineering, performance and economics of this aircraft has recently been given in the second Henson and Stringfellow Memorial Lecture before the Yeovil branch of the Royal Aeronautical Society, by Napier's managing director, Mr. H. Sammons, C.B.E. We give below some of the main points of Mr. Sammons' lecture.

Fig. 1 Standard Convair 340 fitted with Napier Eland propeller turbines.

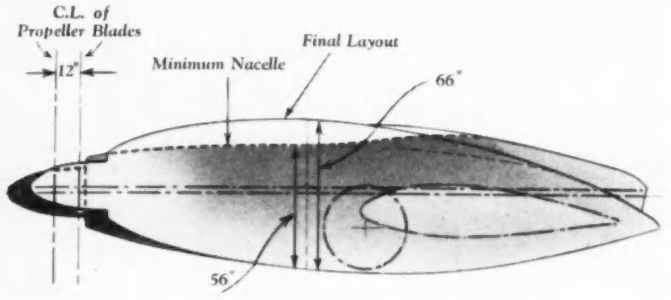


Fig. 2 Comparison of minimum nacelle shape with the layout actually adopted, in which the rear structure was unchanged.

ENGINEERING MODIFICATIONS

In converting a standard Convair 340 airliner to Eland engines, an early decision was made by Napier to retain the original nacelle diameter of approximately 66 in., although the Eland engines could have been installed in a nacelle at least 12 in. less in diameter. However, by changing the engines forward of the existing bulkhead (Fig. 2), the cost of conversion was reduced to a minimum, and the effect on the cruising speed of retaining the large nacelle amounted to only 2 knots.

The major structural changes consisted of local reinforcements to the nacelles to accept the greater torque loads resulting from the higher-powered turbine engines; modifying the nacelle top structure and skin for the installation of the single jet pipe and hot-air muff in place of the twin exhaust and thrust-augmentor tubes of the Pratt & Whitney engines; and installing a stiffer firewall. The existing engine mounting pick-up points were repositioned and the fittings changed from light alloy to steel for greater strength. To avoid the necessity of increasing the areas of the tail surfaces of the standard Convairliner, the take-off power of the 3,500 h.p. Elands is torque-restricted to 3,200 e.s.h.p.

The Eland power plant has been designed either to permit removal and re-installation as a complete power unit, or to enable the engine only to be removed. Such an arrangement allows freedom to select the maintenance procedure most suited to his particular operating conditions. Full accessibility to all parts of the engine is provided by seven bonnet-type cowlings with quick-release toggle fasteners. Complete cowling assemblies can be rapidly removed.

The accessory drives, previously mounted on

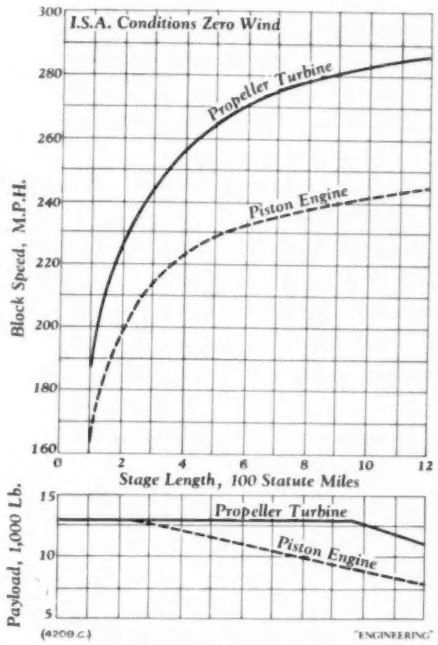


Fig. 3 Comparison of performance of standard Convair 340 with Eland Convair.

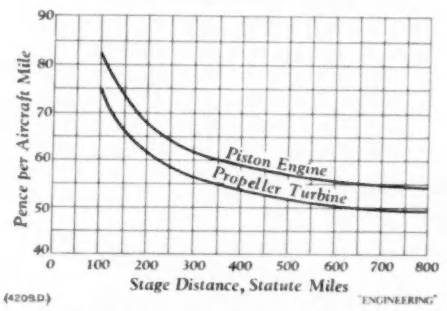


Fig. 4 Comparison of direct operating costs of standard Convair 340 with Eland Convair.

the back of the piston engine, are now mounted on shaft-driven auxiliary gearboxes built on to the main firewall. They comprise 9 kW generators (port and starboard), 3,000 lb. per sq. in. hydraulic pumps (port and starboard), the cabin supercharger (starboard), and a new 40 kVA alternator (port and starboard) in place of a small alternator previously used only for emergency instrument power. The 40 kVA alternator, required primarily for the power-plant de-icing system, also provides an additional emergency direct-current supply through a transformer/rectifier system, giving a third measure of protection on vital circuits.

In the original aircraft, the hot-gas airframe-anti-icing system was cleared by the Civil Aeronautics Authority for operation in " light icing " conditions only. On the turbine-powered airframe, the hot gas is supplied through a muff surrounding the turbine jet-pipe, and it is hoped to obtain C.A.A. clearance for operation in " maximum continuous " icing conditions.

In the fuel tanks, the original positive-displacement booster pumps have been replaced by British centrifugal pumps which have superior vapour and air-separating characteristics. A small air/fuel heat exchanger to protect the low-pressure filter against ice formation operates from compressor bleed air. Combined " gallons gone " and " rate-of-flow " fuel flowmeters are provided.

The cabin supercharger has been modified to single-speed operation in place of the previous two-speed system, as a result of the narrower speed range over which the turbine engines operate. Engine starting is provided by a 120 volt direct-current system, with internal light-weight batteries giving four to six starts without recharging. The batteries are recharged in flight from the alternating-current system through transformer/rectifier.

Comparative Summary o Direct Operating Costs

—	Fixed hourly costs,* £ per hr.	Oil cost, £ per hr.	Fuel cost, £ per hr.	Total cost, £ per hr.	Block speed, m.p.h.	Cost per mile pence.
100 Miles						
Piston engine	41·46	0·51	15·14	57·11	167	82·07
Prop. turbine	46·43	0·62	11·80	58·85	190	74·34
200 Miles						
Piston engine	41·46	0·51	13·61	55·58	200	66·7
Prop. turbine	46·43	0·62	11·05	58·10	228	61·15
300 Miles						
Piston engine	41·46	0·51	12·93	54·90	215	61·27
Prop. turbine	46·43	0·62	10·71	57·76	246	56·35
500 Miles						
Piston engine	41·46	0·51	12·32	54·29	229	56·9
Prop. turbine	46·43	0·62	10·25	57·30	266	51·70
800 Miles						
Piston engine	41·46	0·51	12·07	54·04	239	54·26
Prop. turbine	46·43	0·62	10·18	57·23	279	49·22

* The costs of flying operations (other than fuel and oil) plus direct maintenance plus depreciation.

In comparison with the original aircraft, an increase in take-off power of 2,200 h.p. is achieved with a saving in weight of 500 lb. At the maximum payload of 12,900 lb., the range has been increased from 250 miles to 970 miles, with normal fuel reserves. For a typical 600 mile stage-length, the original aircraft carried 11,250 lb. payload at a block speed of 233 m.p.h. When converted to turbo-propellers, the capacity payload of 12,900 lb. can be carried at a block speed of 271 m.p.h. (Fig. 3). The time to climb to cruising altitude has been reduced by 60 per cent.

A comparison of the operating costs of the Convair 340 with piston engines and with propeller turbines has been based on actual operating data published by the Air Transport Association of America. The depreciation costs for the turbo-propeller airliner have been calculated on the assumption that the aircraft is converted five years after the initial purchase.* Referring to the table, the higher fixed hourly costs of the turbo-propeller airliner are brought about mainly by the cautious assumption that the cost of overhauling the turbo-propeller engine is considerably more than that of piston engines. (The time will come when the overhaul cost for gas-turbines will be less than that of piston engines, but this may not be achieved for some years.) In spite of this conservative view, the final column of the table, and Fig. 4, shows that it pays handsomely to convert to turbine engines, as a result of the higher block speeds achieved.

Assuming that the indirect costs are approximately equal to the direct operating costs, as is usually the case, it can be shown that, at a revenue of 5*d.* per passenger mile, an average load factor of 65 per cent., and an annual utilisation of 3,000 hours, the turbo-propeller Convair operating over a 200 mile stage length, can earn over £35,000 per year more profit than the piston-engined version. On longer stage lengths, the turbo-propeller machine is even more profitable.

* The hourly depreciation cost for the converted aircraft decreases linearly with the number of years of operation before conversion and, on Mr. Sammons' assumptions, it would be uneconomic to convert to propeller turbines until the aircraft had completed at least two years' normal operations.

COAL-BURNING GAS-TURBINE LOCOMOTIVES

American Study Indicates Very Low Operating Costs

The purpose of the organisation known as Bituminous Coal Research, Incorporated, of Dunkirk, N.Y., U.S.A., is sufficiently indicated by its title. In 1944, Bituminous Coal Research formed a Locomotive Development Committee, consisting originally of representatives of six American railroads and three coal companies, to develop means to continue the use of coal as fuel for locomotives; three more railroads and two additional coal companies subsequently joined in the investigation, in which, during the past year, Mr. P. R. Broadley succeeded Mr. John I. Yellott as Director of Research.

A great part of the work of the Committee has been directed towards the development of gas-turbine locomotives, using pulverised coal as fuel. The first operation of a full-scale coal-burning gas-turbine took place at Dunkirk in 1949, the turbine being of the Houdry type. Subsequently, much work was done with an Allis-Chalmers gas-turbine of 4,250 h.p.; this was described in three papers read before the American Society of Mechanical Engineers in 1954. During 1955, the turbine was operated over periods considerably in excess of normal locomotive operating practice, with encouraging results, and for the 1956-57 test programme it was arranged to combine a certain amount of high-load testing (mainly to test the efficacy of sundry alterations to the locomotive coal system) with cycles of operation that would simulate the ordinary conditions of locomotive service. Particulars of the changes made, and of the plan of campaign, are given in the latest report of the Locomotive Development Committee.

The 1955 tests were run with a bin-and-feeder coal system. This handled run-of-mine coals without difficulty, but it was complicated, heavy and expensive, and it was found that about 15 per cent. of the finest pulverised coal was vented in the air discharged from the collectors. A new coal system was therefore developed, to handle coal fine enough to be classed as " fluid." In this system, dried coal of $\frac{3}{16}$ in. by 0 flows from aerated tanks without the aid of mechanical conveyors and it delivered by a rotary pump into the conveying air stream, which carries it through the pressurised pulveriser to the " combustors." The pulveriser was built by the Riley Stoker Company from designs prepared in co-operation with the staff of the Committee.

While this work was proceeding, the turbine was partly rebladed. The new blades were of slightly different design, having the lower portion of the trailing edge thickened, as it was found with the earlier blades that damage occurred, due to a concentration of ash at the roots. Improved blade alloys were also adopted, the materials selected being Haynes Stellite HS-31 and General Motors GMR-235; the new rotor assembly included 45 of the former material and nine of the latter in each row. Other work undertaken was directed to improving the reliability of the Dunlab fly-ash separator.

Briefly summarised, the studies of the Locomotive Development Committee on locomotive arrangements have taken two directions, firstly the substitution of coal-burning gas-turbines, direct-fired, for Diesel engines in existing locomotives, and secondly, the production of designs for new locomotives to be fitted with such power units. One scheme that has been worked out shows that an existing gas-turbine (the English Electric Company's EM27P type) can replace a 2,250 h.p. Diesel engine, and that the necessary supplies of coal can be carried in a tank in the underframe and on the locomotive; this would enable the locomotive to be re-rated to 2,500 h.p., with a cruising range of about 20 hours.

A suggested method of building a direct-fired coal-burning gas-turbine locomotive, which is illustrated in the report by a general arrangement, shows the power plant mounted on a six-motor " power cab," trailing a tender with a capacity of 40 tons of aerated coal. This combination would provide a locomotive of 3,600 to 4,000 h.p. with a cruising range of about 30 hours; and it offers the advantage that a second power unit could be attached, taking its coal supplies from the same tender, giving double the horse-power at the cost of halving the available time of operation.

The economic attraction of the proposals lies in the fact that the cost of the pulverised coal to the railroads and firms represented on the Committee is only about 20 cents per million B.Th.U., whereas the comparative cost of Diesel fuel now approximates to 83 cents.

THE EXPERIMENTAL SPIRIT

7—MORE SPECIAL TYPES; CONCLUDING COMMENTS

By C. R. H. Simpson, A.I.LOCO.E.

This is the final article in the series specially prepared by Mr. Simpson on the attempts that have been made to render the steam locomotive more competitive with the newer forms of traction.

THE LEADER

To Mr. O. V. S. Bulleid's " Leader " class will probably fall the distinction of being the last attempt—at all events on railways in Britain—to depart from the Stephenson form. The only comparable engine in England was the Paget locomotive. Both had a novel wheel arrangement, both employed valve gear of unique design. Also, in each instance, the boiler had the water legs omitted, which eliminated stay trouble but introduced difficulty in another form. The Leader class was carried on two six-wheeled bogies, the centre axle of each being driven by three cylinders receiving steam via sleeve valves. The remaining axles were coupled by chain to the driven axles and particular attention was paid to automatic lubrication of the motion, etc., which were enclosed in an oil bath. The provision of a cab at each end was almost without parallel on a main-line locomotive, the only other instance known to the writer being on a German 4-6-4T built by Henschel & Sohn in 1904.

The designer's expectation that the availability would reach a percentage comparable with that of any other form of traction was, alas, not realised. Had the design been produced 12 years earlier and remained under the aegis of the designer the story would no doubt have had a different conclusion. As it transpired, the class could not have made its debut at a more inappropriate time—at the advent of nationalisation when public criticism of the railways was in full blast. To put it mildly the circumstances were not propitious for even minor departures from the Stephenson form, let alone radical ones. The principal troubles experienced were breakages of valve gear parts, fracture of the crank axles and difficulties with the brick walls of the firebox. The engine weight was excessive and its distribution faulty, the firing cab was excessively hot and dynamometer tests showed no improvement in thermal efficiency.[111]

GEARED LOCOMOTIVES

As these articles are concerned with attempts to improve on the Stephenson form of locomotive it is not necessary, under the heading of geared locomotives, to consider those powered by turbines, in which gearing was a necessity unless electrical transmission was employed.

In early American practice geared locomotives were used fairly extensively; in those days speed had not assumed the importance it later acquired, nor had the costs of the increased maintenance—associated with geared drive—become high. The chief reason for its employment was the ability to use a driving wheel of small diameter and thus keep the centre of gravity low—then regarded as a desirable feature of design. Incidental advantages were the improved torque and consequent ability to handle loads at low speeds which would have stalled the orthodox locomotive. Advantages not appreciated at the time, but realised later, were the increased thermal efficiency resulting from higher engine speed, and the possibility of employing higher pressures in smaller cylinders. In a geared locomotive the prime mover may be totally enclosed in an oil bath and it may be entirely spring-borne. As the balancing of reciprocating parts is effected within the main engine unit itself, hammer blow on the rails is entirely eliminated.

The attempts of Fontaine[112] and later Holman[113]—the latter's being particularly freakish—to introduce gearing into engines otherwise of the Stephenson form are well known. They are shown opposite. Apart from these the use of gearing in conjunction with reciprocating engines was to lay dormant, except for industrial applications, until the advent of individual axle drive.

There were many examples of geared locomotives built for industrial use; the Sentinel is the best known and is widely used in Britain. There have been other British builders, e.g., Clayton Wagons Limited. American builders were Baldwin, Lima, Bell, Porter, Vulcan, Davenport, Heisler, and Climax. All of these engines were relatively small and it will suffice if reference is confined to those of 60 tons or more in weight. In the Baldwin geared locomotive[114] the cylinders occupied the usual position and drove a jackshaft connected via bevel gears to longitudinal shafts which transmitted power to bogies.

The Lima Locomotive Works were builders of the Shay locomotive, large numbers of which were constructed for use where the going was hard and the track indifferent. The three vertical cylinders drove longitudinal shafts connected to bevel gears mounted on the axle ends. The arrangement necessitated the boiler being offset from the longitudinal centre-line. The layout was not suited to operation except at low speeds. Whereas considerable maintenance was required, a favourable feature of Shay locomotives was the extraordinarily good accessibility. An incidental aspect of Shay locomotives was that Lima did not recommend counter-pressure braking. The last Shay locomotive to be constructed was one for the Western Maryland Railway in 1945. With three 17 in. by 18 in. cylinders, 200 lb. per sq. in. boiler pressure and 4 ft. diameter wheels, this engine, which weighed 145 tons, developed a tractive effort of 59,740 lb.

The Leader class locomotive.

AUTOMATIC CONTROL

A disadvantage of the steam locomotive compared with Diesel and electric units is the inability to leave it standing unattended for lengthy periods. This requirement is, of course, most likely to occur on an engine used for shunting. To overcome this objection Mr. R. G. Henly, of the Norfolk and Western Railway, equipped a locomotive with automatic firing, boiler feed and draught control. So fitted it was possible to leave the engine for long periods and yet have it ready for service in a few minutes. There was provision for cutting out the automatic features and reverting to hand control when desired.

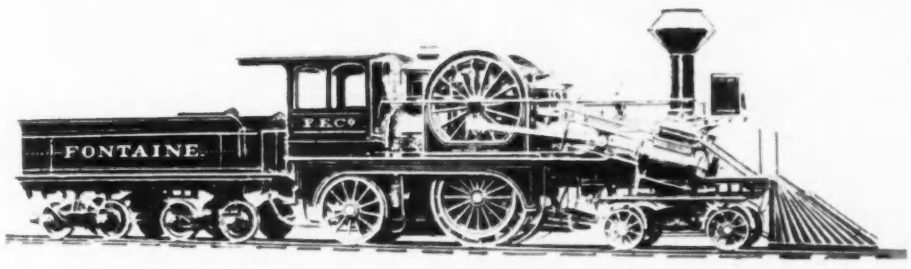
A fan driven by a live-steam turbine was installed in the smokebox to provide induced draught and the exhaust from the cylinders was discharged direct to atmosphere through a separate chimney. Dispensing with the blast nozzle, and consequently reducing back pressure, naturally increased cylinder horse-power; but a claim of prior importance, where an engine was employed on heavy shunting work in a built-up area, was reduction of noise. The fan, housed in a forward extension of the smokebox, had a seven-bladed rotor of 42 in. diameter; operating at maximum output it required 4,000 lb. of steam per hour. Vertical baffles were placed between the front tube-plate and the fan to trap large cinders, which were collected in hoppers at the bottom of the smokebox and returned to the firebox by steam-operated ejectors. Draught was further automatically controlled by steam-operated dampers.

An automatic controller, mounted on the backhead, maintained boiler pressure at a pre-determined figure. When pressure fell below this, pneumatically-controlled valves operated the fan, set the stoker in motion, and controlled the amount of primary air in a fixed ratio to the rate of firing. A steam-driven feed pump automatically attended to the water requirements. The operating speed of the fan was controlled by a governor actuated by the differential of the firebox and smokebox draughts.

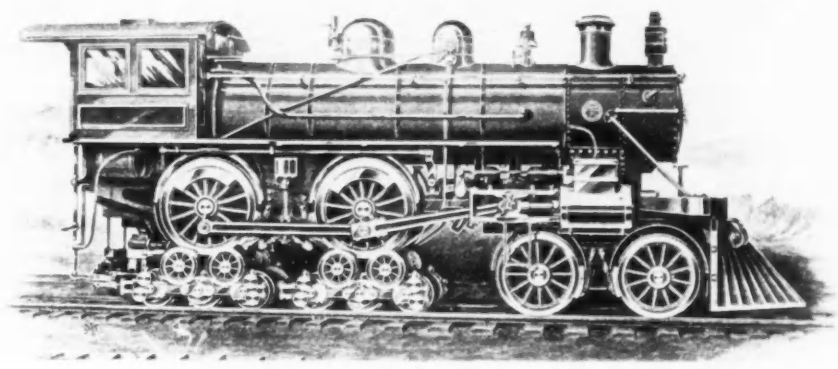
While no one, before or since, carried automatic operation to the length described above, there had been a previous attempt to make a steam locomotive competitive with an internal-combustion one, by dispensing with the fireman. In 1935 the Baldwin Locomotive Works built an oil-fired shunting locomotive in which the firing was automatically controlled by the boiler pressure. The makers claimed that there was no waste of fuel or water—as blowing off did not occur—and as no ash dumping or visits to coal stages were necessary it probably carried availability for this type of steam locomotive about as far as it could be carried. One-man operation has, of course, been employed elsewhere, e.g., in Switzerland.[115]

WINTERTHUR HIGH-PRESSURE LOCOMOTIVE

The Winterthur high-pressure locomotive[116] was built by the Swiss Locomotive and Machine Works in 1928. It had a water-tube boiler, working at 850 lb. per sq. in., which supplied steam to a three-cylinder high-speed engine which transmitted its torque through gearing, having a ratio of 1 to 2·5, to a jackshaft and connecting rods. Tests conducted against its conventional equivalent and evaluated on a drawbar horse-power hour basis showed a coal economy of from 35 to 40 per cent. in favour of the high-pressure engine, and water saving of from 47 to 55 per cent. Thermal efficiency, as



Fontaine locomotive geared to give the equivalent of a 7 ft. 6 in. wheel.



Holman trucks fitted to an American locomotive.

every designer of unconventional locomotives has had to find out, is not everything. In fact it is only a relatively small matter. When such locomotives are tested it may always be assumed that the engine is in good condition, the engine crew are selected for their intelligence and the fuel is the best available. Many an idea which produced a saving on test, when put into ordinary service with perhaps the engine run-down, men who were not particularly interested, and poor fuel, so far from showing any saving has resulted in a loss. Every locomotive man will be familiar with such cases. The particular circumstances of the Swiss locomotive are not known to the writer, but the design did not survive. So far as unorthodox types went this locomotive was a relatively simple one.

THE FRANCO ARTICULATED LOCOMOTIVE

There have been many types of articulated locomotive, most of them in the Stephenson form. Two of these emerged as particularly suitable: the Beyer-Garratt and the Mallet. Many hundreds of each were built, but to-day only the Beyer-Garratt appears to be called for. The " Franco " articulated locomotive[117] was remarkable for several reasons, apart from the fact that it was the last-comer to challenge established forms which got as far as being built. Constructed in 1932 by Atéliers Métallurgique at Turbize, it must have been one of the most complicated locomotives ever conceived. It was in three units so giving a 0-6-2+2-4-2-4-2+2-6-0 wheel arrangement—a relatively simple locomotive compared with a design prepared for Russia which was a 2-4-4-2+2-8-8-2+2-4-4-2 ! Each of the units of the Belgian locomotive had its own set of cylinders (eight in all, 17½ in. by 25⅝ in.) fed from a double-barrelled boiler, carried on the central unit, having a heating surface of 2,700 sq. ft. The boiler basically resembled the double-barrelled ones employed on some Fairlie locomotives, even to the extent of having the firebox divided by a diagonal leg; such an arrangement necessitated a fireman on each side. The outer units carried feed heaters, through the lower tubes of which the exhaust steam passed, while the upper tubes carried the firebox gases.

On a test run of 94 miles with a train of 1,200 tons, the water evaporated was 176,500 lb. and the coal burned 17,730 lb. Even if the claimed coal economy of 20 per cent. had been achieved, such complication, and with it increased maintenance, could never have resulted in this form of locomotive being a serious competitor. The work of preparation would have been enormous, and the first cost must have been exceedingly high.

MISCELLANEOUS

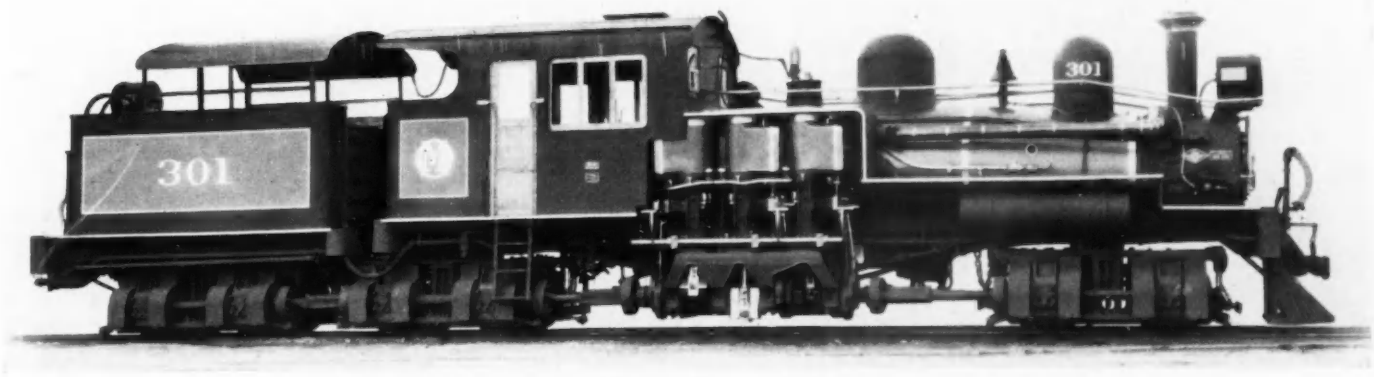
In the early years of this century spring-supported footboards were fitted to all locomotives constructed by the Société Alsacienne de Constructions Mecaniques; the compound " La France," supplied to the G.W.R. was so equipped. It is somewhat surprising that this idea was not adopted more widely for many British locomotives were notoriously bad riders; a L.N.W.R. locomotive down on the springs was unbelievably rough and sprung footplates would have saved much wear and tear of enginemen.

The Paris Exhibition of 1900 included two locomotives (a 4-6-0 for the Italian Adriatic Railway, and an engine built by the well-known firm of Schneider and Company, with the unusual wheel arrangement of 4-4-6) both of which had the cab at the front. In the Italian engine this was achieved by turning the boiler end for end; in the French engine no less than three enginemen[118] were required, the driver in the front cab being in speaking-tube communication with the two firemen in another cab behind the firebox. The idea of a front-end cab was later used fairly extensively by the Southern Pacific Railroad of America and was tenatively employed prior to the second World War in Germany. In addition to excellent visibility it can give benefits from purer air in tunnels with a foul atmosphere. It can only be really successfully employed when liquid or pulverised fuel is used.

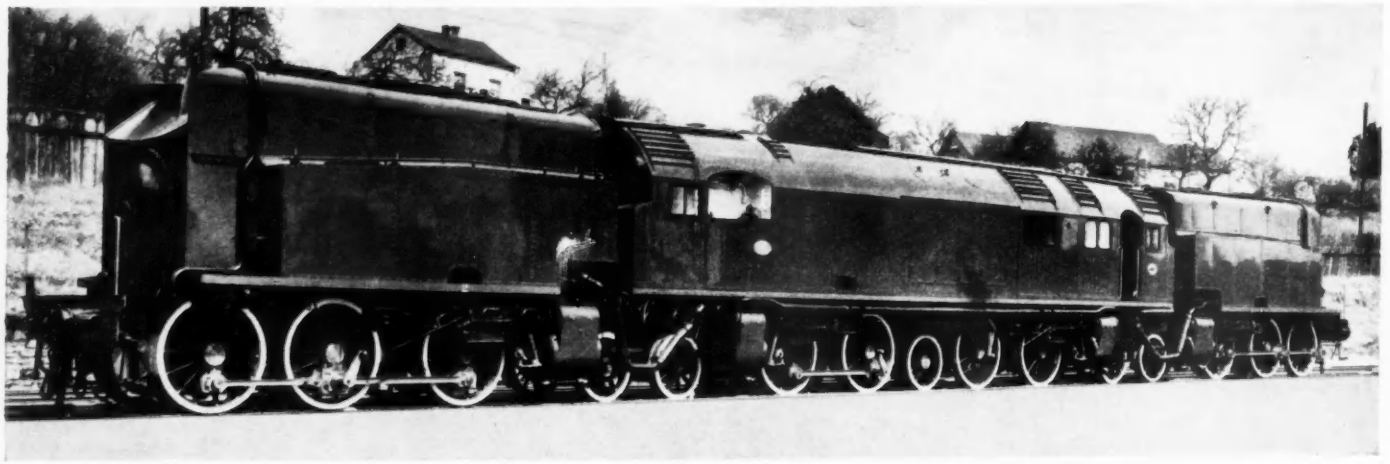
While it can be scarcely considered as an attempt to improve upon the locomotive, the use of a ball and socket little-end is an interesting feature. It will be recalled that the Rocket had a ball and socket big-end and this type of little-end was used by Deeley in some Midland Railway locomotives built in 1907-9.[119] These engines had 1 in. difference between the cylinder and crankpin centres; the use of a ball joint enabled this difference to be accommodated. and in addition it relieved various joints of the valve motion—which was of the cross-driven type—from strain.

CONCLUSIONS

The fact that the locomotive has basically altered so little could only be due to two causes: either suitability in its original form for the work it was called upon to perform, or want of endeavour to improve on the original basic form. This series of articles by no means comprehensively surveys the attempts made to improve on the Stephenson form, but sufficient evidence has been produced to show that there was no lack of attempts. An idea which may have had attractions at the time of its introduction sometimes ceased to be of interest either owing to improvements in the orthodox locomotive or because it was eclipsed by another development. As an example of the former, the Smith compound with its short-travel valves ultimately showed less economy than the simple engine with long-travel long-lap valves. Many patents have been taken out to cure ills which were non-existent or not particularly apparent. In some instances the



The Shay locomotive with vertical cylinders driving through gearing and shafts.



Franco Locomotive.

" cure " made things worse. In this respect even the most prominent people were apt to nod—a classic case being Baldwin's use of brass tyres to increase adhesion.

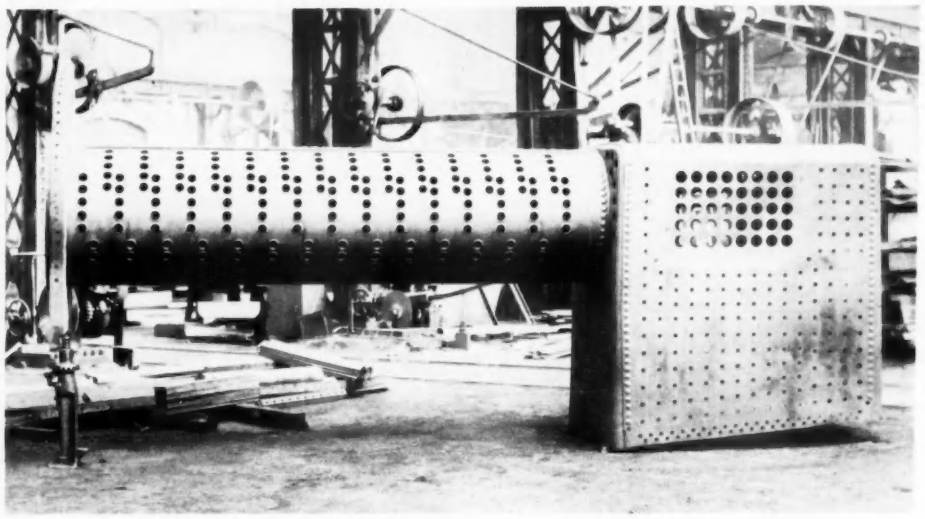
It is not unknown for an idea to be used, cast aside, and resuscitated many years later when conditions have altered to such an extent that it can be employed advantageously. An example is the use of chains for coupling axles, employed by George Stephenson at Killingworth. These disappeared from the scene—except for a few applications on industrial locomotives—for one-and-a-quarter centuries, until they re-appeared in Mr. Bulleid's Leader class locomotive. A further example was the axlebox split vertically. This was patented in 1858 (Specification 315) by Joseph Beattie and used on his 7 ft. engines. The idea also formed the subject of a patent taken out by F. W. Webb (No. 3442) in 1871 and was later to be used by Mr. Bulleid for driving boxes. Truly, history repeats itself.

Many ideas were incapable of interpretation into practical form at the time of their inception—and even if the state of the art had permitted their working satisfactorily they would not have been serious rivals of the orthodox locomotive. In 1861 M. A. F. Mennon obtained a patent (No. 1633) for " a furnace-gas engine of the turbine type," while jet-propulsion had its advocate in J. Robertson, who patented his idea in 1868 (Specification No. 3146).

Though it is sometimes contended that ideas which could have improved the steam locomotive were not given trials, rather does it appear that not only were likely devices tested but also some most unlikely ones.

D. Drummond's experimental water-tube boiler, of which the inner firebox and flue are illustrated, was an impossible proposition when any maintenance work was required on the cross water tubes in the flue. Even keeping the cross tubes clean externally must have presented extreme difficulty. However much fuel might have been saved the idea could never have been an attractive one.

The alterations which have been made to the Stephenson form of locomotive have led to enormous improvements over the last half-century. Although the locomotives of 1906 and 1956 are basically similar the latter engines are, in addition to being far more powerful and generally less temperamental, thermally more efficient. Designers have certainly not laboured in vain, especially in the years immediately preceding the second World War. The overall thermal efficiency of a locomotive on an I.H.P. basis, expressed as a percentage rose, from 5·2 for a representative saturated engine of about 1880 to 7·2 for a representative superheated engine of about 1912. The L.M.S. " Coronation " achieved the figure of 10·8, and a Chapelon 4-8-0 compound 12·8.[120] It cannot be too strongly emphasised that the locomotive, in the Stephenson form, was an excellent traffic machine, and excellence in this direction was of much



D. Drummond's firebox and flue with cross water tubes.

greater importance to a railway—especially so when coal was comparatively cheap—than excellence as a thermal machine. The improvements resulting from better design resulted in some thermal improvement but the greater output of power, usually at higher speed, was of greater import to those engaged in running the railway.

A locomotive in the early years of this century delivered 1 d.b.h.p.-hour on a consumption of just over 2 lb. coal.[121] As one first-class passenger was regarded as paying the coal bill it will be understood that some locomotive superintendents did not go to great lengths to effect savings.

Mr. R. C. Bond pointed out, in his Presidential Address to the Institution of Locomotive Engineers in 1953, that between 1923 and 1953 the coal consumption on new locomotives in Britain was reduced by more than 30 per cent.

A fact which sooner or later impresses the student of locomotive history is that while the forms used by different, but contemporary, designers are similar, the ratios adopted have differed widely. As an example, the cross-sectional area of the tubes in relation to the grate in the Canadian National 4-6-4 was 8·9, whereas in a German State Railways 4-6-2 it amounted to 18·03.[122] Considerable improvement has resulted to the locomotive from extraneous developments. Hot-water washing out, the treatment of feed water, improved repair facilities, etc., have all helped to increase availability, which is the strong point of competitive forms of motive power. Boiler washouts and firebox examinations, calling for 18 hours out of service during every 12-16 running days, were the weak link in the operation of the modern locomotive.[123]

At least one item of equipment designed to benefit the locomotive has had to be abandoned, at least in its original form, because it conflicted with the interests of the civil engineer's department. Continuous blowdown was blamed for bad condition of track and received prominence in this connection following the derailment at Watford in 1954.[124]

Despite the enormous strides made in locomotive development it is somewhat surprising that the mileages obtained per month have improved little in Britain during the last half-century. In 1906 L.N.W.R. locomotives making daily round trips from Liverpool to London were covering 2,322 miles per week.[125] Leaving 42 working days per annum for examination and repair; this is equal to over 104,000 miles in 45 weeks. In 1948 the average of 45 L.M.R. " Pacifics " was 67,000 miles in the same period.[126] The latter figure is in part due to unsuitable schedules. It has already been said that the Stephenson locomotive is a good traffic machine. In 1938 when maintenance standards were high, the average mileage run per failure on the Southern Railway was 131,264 miles[127]—a high figure. Where utilisation enabled full advantage to be taken of availability, mileages could be high, as for example in America where monthly mileages of 25,000, with mileages between overhaul of some 200,000, were common.[128] The latter figure has been exceeded by Beyer-Garratt locomotives working on the Rhodesia Railways, where mileages, between general stopping, of some 250,000, have been frequently attained.

The fact that a device, e.g., an extra inlet for secondary air, produced most excellent results, was not necessarily testimony to the excellence of the device. It may merely have been acting as an antidote to a defect in the design, which if remedied would have produced equally good results without the equipment concerned. This

explains why items which produced substantial benefits when fitted to one class of locomotive did not necessarily show improvement when used on other engines.

While the steam locomotive may be regarded by some as not having progressed far, in that it has retained the Stephenson form, the progress has in fact been considerable. In slightly more than 100 years " The Rocket " had as its direct descendant a locomotive capable of developing 6,500 h.p. at 100 m.p.h. The engine concerned was the Pennsylvania Railroad 6-4-4-6, with a heating surface of over 7,700 ft. The tender alone weighed, in working order, nearly 30 times the engine and tender weight of The Rocket. Progress indeed !

The Stephenson form, as Sir William Stanier once pointed out,[129] had simplicity and flexibility, combined with the fact that its intrinsic characteristic, as represented by the tractive effort speed curve, was exactly what it should be for railway work. This characteristic, the result of the expansive properties of steam and of direct drive, was unobtainable without complication from any other form of power.

The Stephenson locomotive had its heyday in Britain in the 1930's, when advantage was taken of all modern developments in front-end design, good valve-events, high superheat, etc., combined in proper relationship. For many years the locomotive had suffered from a want of balance between boiler output and cylinder sizes, and when these proportions were correct the valve events and front-end arrangements were such as were not conducive to optimum performance.

Though many of the devices introduced to better the steam locomotive were in themselves failures, they sometimes led to improvements: arising from the better understanding which was obtained by carrying out investigations into the behaviour of the new idea in contrast to established practice.

Note

It was somewhat misleading, when referring to the firebox of the " Great Bear," to describe it as narrow. The intention was to imply that the box was not as uniformly wide as the Wootton one fitted to the Ivatt large-boilered Atlantic built five years earlier. Measured across the front of the box the width was the same for both, but the Great Western engine's box, measured at the backhead, was 5 ft. 9 in. wide against the 6 ft. 9 in. of the Great Northern locomotive. Both were wide fireboxes.

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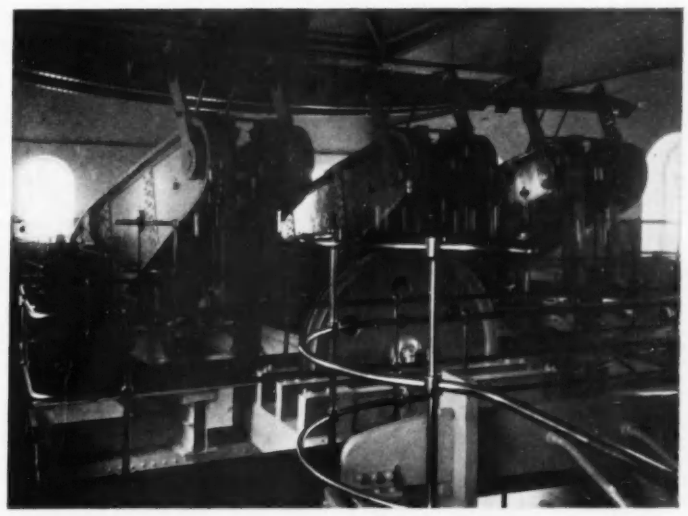
ELECTRIFICATION OF THE SEVERN TUNNEL PUMPING STATIONS

There can be few, if any, steam pumping installations which have achieved the fame of those used for the drainage of the railway tunnel under the River Severn. Now, according to a statement from British Railways, Western Region, the days of this fine collection of steam engines, principally of the orthodox Cornish type, are numbered, for 12 electrically-driven submersible-type pumps are to be installed in their place.

The existing plant comprises 14 steam-driven pumps in three groups, 10 of the pumps being at Sudbrook, on the Monmouthshire bank of the river, two at a point known as " 5 miles 4 chains," close to Sudbrook, and two at Sea Wall, on the Gloucestershire side. Most of the engines are of the ordinary Cornish type, with overhead beams, but there are two Bull-type inverted engines at Sudbrook, and there is also, at this station, a tandem compound horizontal engine driving a fan, 27 ft. diameter and 9 ft. wide, which ventilates the tunnel. The bringing into commission of these permanent pumping engines marked the virtual completion of the Severn Tunnel, which was opened for passenger traffic on December 1, 1886, having been passed by the Board of Trade Inspector in the previous month. During the construction of the tunnel, which is 4 miles 624 yards long, much trouble was experienced with water, and a considerable amount of temporary pumping plant was used. To-day, the quantity of water pumped at Sudbrook, the principal station, varies between 13½ and 22½ million gallons a day, the greater part coming from the " Big Spring," which was responsible for so much of the construction difficulty.

The electric pumps will be twelve in number at Sudbrook, each of them being capable of dealing with about 200,000 gallons an hour, while two similar pumps, but each of 120,000 gallons an hour capacity, will be installed at Sea Wall. The plans also provide for the conversion of the ventilating fan to electric drive. Allowance is being made for 100 per cent. standby facilities, both in electrical and pumping plant, and standby Diesel generators will be installed to meet the maximum pumping demand.

The railway authorities intend to preserve, *in situ*, the cylinders, beams and working gear above ground level, of the engines in No. 1 pump house, and are considering making provision for the setting in motion of one of the beams and its working gear. The house contains six 70 in. Cornish engines by Harvey and Company, Hayle, Cornwall, arranged to lift from a central well, 29 ft. in diameter. All the engines, which are of 10 ft. stroke, are identical, but three of them work plunger pumps while the other three are connected to bucket pumps. It is particularly gratifying to learn that this set of engines is to be preserved. They have all served faithfully the purpose for which they were installed over 70 years ago, and they are still working. It is economics which will silence them at last. They will be a fitting monument to the steam era, which produced some fine engineers and some fine machines.



Three of the six 70 in. Cornish engines which will be preserved by British Railways when the Severn Tunnel pumping plant is electrified. The other three are in the same engine house and pump from the same well.

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MARINE GAS-TURBINE TO RIVAL DIESELS

Less Weight, More Economy

A new 1,000 h.p. gas-turbine—the Saturn—is under development by Solar Aircraft Company, San Diego, U.S.A., for the United States Navy. It is smaller and lighter than existing gas-turbines of less power, and its fuel consumption is expected to be lower than any other gas-turbine in a similar power range. The Saturn will have widespread application for marine propulsion and the first engine will go into a new type of landing craft.

It will weigh only 500 lb. compared with 10,000 to 20,000 lb. for marine Diesel engines of similar power. The overall length of the new engine will be about 5 ft. and it will be about 2 ft. wide and deep. In marine applications the Saturn will burn less fuel than present Diesel engines when it is operating at speeds of about 30 knots. Although the Diesel's specific fuel consumption is lower than that of the gas-turbine, the latter burns 20 lb. less fuel every hour at 30 knots, owing to the much heavier weight of the Diesel installation.

The Saturn is a variable-speed engine with an eight-stage axial-flow compressor and a three-stage axial-flow turbine. Two stages of the turbine power the compressor and the remaining stage drives the shaft. An annular combustion chamber will be used, affording the advantages of symmetrical design and minimising ducting losses. Start and acceleration will be completely automatic. The engine will operate 2,000 hours between overhaul inspections and will be designed to run on Diesel fuel. It is also suitable for alternating-current generation.

100 SWITCHES IN A THIMBLE

Application of Superconductivity at Low Temperatures

The establishment of the mechanical nature of certain branches of logic allowed the use of machines to solve a variety of logical problems. Probably the most well known of the early machines was the "logical piano" developed by W. S. Jevons at the end of the last century. This instrument solved problems in Boolian algebra or symbolic logic. However, the emphasis has shifted from logic machines, which find little application, to digital computers, which are rapidly becoming an indispensable research tool. But Boolian algebra has survived, having been incorporated in switching algebra, and as such is used in the design of computer circuitry. For the algebra of logic, created to introduce mathematical rigour into a part of philosophy, is based upon the relationships among two valued variables. Consequently, it may be readily applied to machines containing devices which limit a variable to two stable values.

In early computing machines the variable was usually mechanical displacement and the bistable device was a lever. Later machines had electric current as the variable and a switch as the bistable device. When the advantages of digital computers were realised, considerable attention was directed to bistable devices in electric circuits. Fundamentally, the requirements of such a device are reliability, speed, simplicity, and low power consumption. Also a current gain must be achieved. That is, the current that the device controls must be greater than the current that controls the state of the device. This is because large numbers of such devices are connected in various manners, one controlling another, when logical or arithmetical operations are to be carried out. The need for speed should not be underestimated, for it is this property alone that removes the solution of problems from the realms of impossibility.

MAGNETIC CONTROL

In the interests of faster operation, thermionic valves replaced relays. Transistors offer low power consumption, small physical size, and simplicity, and although there are still problems to be solved before they can find widespread application in computers, it would seem likely that transistors will supersede valves. The latest bistable device to attract attention is the cryotron, development of which was begun three years ago by Mr. D. A. Buck of the electrical engineering department of the Massachusetts Institute of Technology, in co-operation with the Lincoln laboratory. For his first report on cryotron research, published by the, Institute of Radio Engineers in April, 1956, Mr. Buck will receive the I.R.E.'s 1957 Browder J. Thompson Memorial Prize.

The phenomenon of superconductivity—the basis of the cryotron's operation—was first discovered by Onnes in 1911, three years after he succeeded in liquefying helium. It is now known that 21 elements and many compounds and alloys lose their electrical resistance completely when cooled below a critical temperature. The critical temperature at which superconduction occurs varies from within a fraction of a degree of absolute zero to 17 deg. K, depending on the material. Elements that have low resistance at room temperature—gold, silver, copper—do not show superconductivity. The fact that below the superconductive transition temperature the resistance is truly zero has been convincingly demonstrated. A current of several hundred amperes was started in a lead ring kept at less than 7 deg. K. Two years later there was no detectable change in current magnitude although no power had been fed to the ring once the current had been started.

The two states of the cryotron are the superconducting and the normal state. The transition can be achieved by raising and lowering the ambient temperature. However, it is much easier to effect the transition by the application of a magnetic field, since this will depress the temperature at which the superconductive transition takes place. It is found that if a superconductor is held at about 0·2 deg. K below its zero-field transition temperature, the superconductivity can be inhibited by relatively small magnetic fields—1,000 to 2,000 amperes per metre. A typical cryotron is made up of a control winding, consisting of an insulated wire of niobium, 0·003 in. in diameter, which is wound around a bare tantalum wire, 0·009 in. in diameter, called the "gate." The insulated winding produces a field strength of 3,100 amperes per metre at its centre. Liquid helium surrounds the whole device.

At atmospheric pressure the boiling point of helium is 4·2 deg. K. The zero-field transition points of niobium and tantalum are 8 deg. K and 4·4 deg. K, respectively. Thus the control winding is always superconducting since the field strength is never sufficient to cause inhibition. The tantalum, on the other hand, may have its superconductivity destroyed by a relatively small field, as it is only about 0·2 deg. K below its zero-field transition temperature. The fact that the liquid helium may be used at atmospheric pressure is particularly useful. If higher or lower operating temperatures were necessary the equipment would have to be pressurised and all lead-in wires would have to be sealed.

SMALL DISSIPATION

The use of superconducting materials means that the power consumed by the device is extremely small. The average power dissipated by a cryotron is 10^{-4} watt, so that a large computer containing 5,000 of these devices would consume about $\frac{1}{2}$ watt (excluding the refrigeration equipment); in conventional computers the power requirements are measured in kilowatts. The form of the power supply is simple: a battery with a series resistance is sufficient. The reliability of the components is not known, but the fact that they operate in an inert atmosphere at a temperature at which chemical and diffusion processes virtually cease suggests that a high degree of reliability might be expected. Other materials such as insulators (enamel, silk, glass, etc.) appear to be quite suitable for operation at temperatures close to absolute zero. Metals generally are very much stronger under such conditions.

The refrigeration would seem to be the outstanding engineering problem. However, techniques have improved considerably during the last decade. The liquifier at the Massachusetts Institute of Technology will produce liquid helium at the rate of 27 litres per hour. It is possible to store this in double Dewar flasks, using liquid nitrogen to fill the outer Dewar—less than 1 per cent. of the helium evaporates per day. Assuming a 5,000 element computer with a dissipation of $\frac{1}{2}$ watt, an evaporation of about one litre per hour is to be expected. Thus a stationary computer would probably be economical if used with a continuous refrigeration system. Portable systems should be possible if equipped with a storage capacity of 10 to 20 litres. Portable computers could be embodied in missiles or satellites.

The very small physical size—100 fit in a thimble—and extreme simplicity of the cryotron make it ideal for computers. It has been estimated that a typical computer would occupy about half a cubic foot, exclusive of refrigeration equipment. In addition, the manufacturing techniques required would be greatly simplified, it being possible to assemble large banks of cryotrons with comparative ease. The chief disadvantage is lack of speed. A cryotron computer is at present only slightly faster than an electric relay computer and much slower than one employing vacuum tubes. The slowness is caused by the presence of a large inductive component in the cryotron impedance. The effect of this may be made negligible by increasing the cryotron resistance in the normal state—a procedure similar to that of raising the speed of response of rotating electrical machines by increasing their field resistance. There are various ways of decreasing the L/R time constant; it is independent of the length, and decreases as the fourth power of the diameter, of the gate circuit. However the power gain decreases as the diameter decreases and if, by increasing the pitch of the control winding as the diameter decreases, the power gain is held constant, the time constant varies as the square of the diameter.

SPEED IMPROVEMENT

The current gain of a cryotron is proportional to the diameter and thus for speed the gain must be kept as low as possible. A value of 2 appears to be the most favourable. Circuit speed can also be increased by using alloys with a high normal resistivity and by using hollow wires, i.e., reducing the cross-sectional area of the conductor. This last technique is quite feasible since the superconducting current only flows in the outer skin of a conductor, in a layer a few hundred atoms thick. The core of the conductor need not be removed provided it has a high resistivity. One solution would be to form a superconducting shell by vapour plating. At the present state of development the observed time constant is of the order of the calculated L/R time constant. The next increase in the order of magnitude of the speed should make eddy-current effects important. The time constant of this effect is also proportional to the square of the diameter and is effective during the transition from the superconducting to the normal state. The reverse transition is interesting in that delay is caused by the length of the gate circuit. It is reported that a nucleus of superconducting material forms at a spot, sweeps round the wire, and then grows along the wire. Experiments performed on materials that go through this transition relatively slowly enabled Mr. Buck to estimate that, with cryotrons of current gain 2, velocities of the order of 10 cm. per microsecond could be expected. A final speed limit exists in the form of relaxation losses. Extrapolation from other experiments puts this limit at 100 to 1,000 Mc/s.

An important property of the cryotron is the fact that the direction of the total magnetic field present has no effect on the value at which the superconductive transition takes place. Thus the switching action is independent of the direction of the current in the control winding, and the current in the gate circuit may also be in either direction. The device lends itself readily to circuit design, flip-flops, multivibrators, binary adders, etc., all having been constructed.

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SUBMERSIBLE DRAINAGE PUMP

A completely submersible drainage pump has now been put on the market by Sumo Pumps Limited, Crawley, Sussex. Mainly for use on contractors' sites, it is shown in the two illustrations. Bearing in mind the conditions normally encountered on building sites, the construction has been made extremely rugged. The pump stands in a vertical position, and at the base is a grid of $\frac{3}{8}$ in. square holes which acts as a filter for the incoming water. Any matter that will pass through this grid can safely be handled by the pump, whether it is gravel, sand or earth. The main construction is shown in the diagram. Two sizes of impeller are available, one with two blades for dealing with heads up to about 50 ft. and one with four, which is satisfactory up to 60 ft. The water passes from the impeller round the outside of the electric motor, and thence up through a central delivery pipe. The motor is basically the same type as has been used in the submersible well

pumps made by the company, but in this case runs in an oil bath. The stator windings of the motor are sealed between the outer walls of the motor housing and a thin stainless steel tube internally, within which is the squirrel cage rotor. The light-oil filling lubricates the lower journal bearing, and the upper, which also takes the thrust load, is situated in a grease filled compartment.

The impeller and wearing ring surrounding its inlet are easily removable for inspection and replacement and these are the only major components of the pump which are liable to wear from abrasion. The main body and end caps are made of aluminium alloy. Provision is made in the pump inlet for a hose connection from an external water supply, which can be used both to clean out the chamber and also to dilute an excessive intake of sludge. The water passing round the outside of the motor normally supplies the cooling for it, but the pump can run for some time completely dry, under the protection of an automatic re-setting thermostat embodied in the stator housing. Thus, the pump can be left running, completely unattended.

The pump can operate on full bore, completely or partly submerged, and can also run "on snore." It can be suspended by its rising-main pipe, or by ropes to allow the use of flexible hose, or it can stand on its own base. Power for the motor is fed through a flexible multi-core cable, from a starter. A special starter has been developed for use with this pump, which is mounted on a tripod for convenience, and incorporates an earth leakage protection. (One leg of the tripod forms the earth connection.) The starter also incorporates the thermostat connections and the over-loads for ordinary running. The latter are of the thermal type, and are also temperature compensated. An inter-lock switch under the lid of the starter box automatically trips the pump if the lid is removed. The starter is proof against normal rain, but is not guaranteed submersible as is the case with the pump unit.

The complete pump weighs 238 lb. and can be rolled on its flanges or like a milk churn, and is not damaged by being dragged, even over rough ground. A prototype model has run for over 4,000 hours continuously without failure. With the four-blade impeller the delivery is 15,000 gallons per hour at a total head of 30 ft. or 6,000 gallons per hour at 60 ft.; with the two-blade version the corresponding figures are 15,000 gallons per hour at 17 ft. or 5,000 gallons per hour at 50 ft. The two impellers are directly inter-changeable. The standard motor is wound for 440 volts, 50 cycle, 3 phase supply, and is rated at 6·5 h.p. It is understood that the model now available is the first of a series which will include several sizes.

Fig. 1 Designed for work on civil engineering sites, the drainage pump can work completely submerged or "on snore." It has a delivery up to 15,000 gallons per hour.

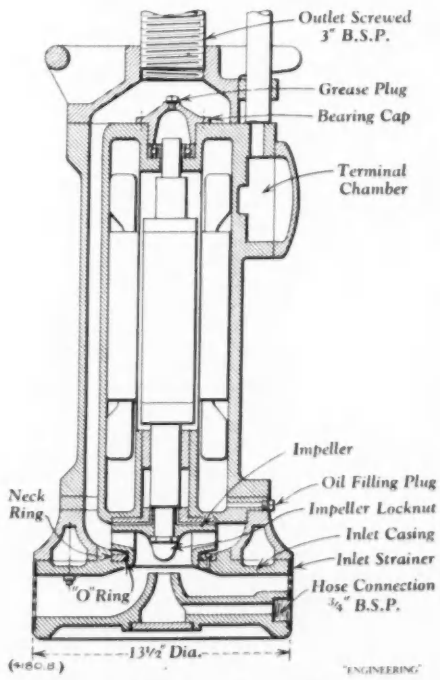

Fig. 2 Suspended matter up to ⅜ in. square can safely be handled by the impeller. The oil-filled motor is cooled by the discharge which passes up around it.

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ANALOGUE FOR HEAT FLOW STUDIES

Resistance Network Computer

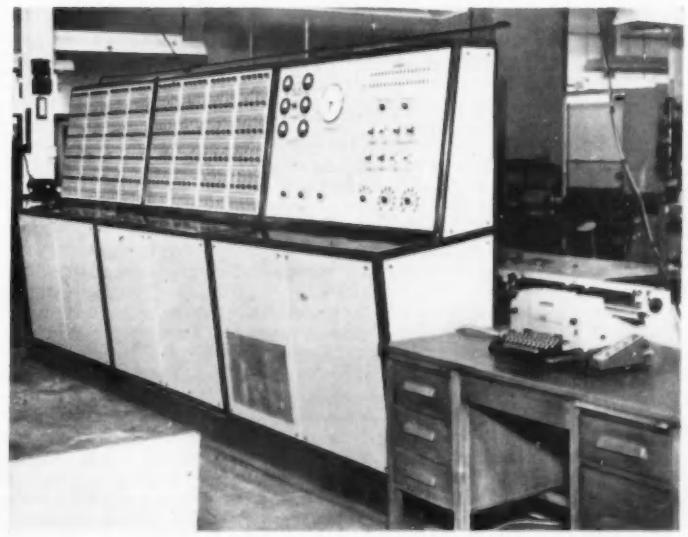
An analogue computer intended for the study of heat-flow problems has recently begun service at the Imperial College of Science and Technology, University of London. It is the Sunvic resistance network analogue computer and has been constructed for the Admiralty to be used for studies associated with the design of steam and gas turbines. The computer can also be used to study more complex heat problems and those which are represented by the same forms of differential equations, for example, problems of diffusion and mass-flow. The design of the computer is based on a manually operated apparatus which was developed by the late Dr. Liebmann of the A.E.I. Research Laboratory, Aldermaston.

In this method, electrical networks represent the finite difference equations which replace the differential equations governing the problems to be solved. Temperature is represented by voltage, the spatial features of the problem by a network of parallel resistances, and the thermal constants by these and series resistances. A solution in discreet intervals of time is obtained by successive readjustment of potentiometers supplying the voltage to the network. This method, similar in character to certain numerical methods though much faster, is very flexible, the thermal constants being adjustable during the progress of the work. It can be applied to problems of considerable complexity, and can be adapted for the solution of heat-transfer and heat-generation problems, and those where latent heat plays a part.

The computer contains two sets of two hundred special single-turn slide wires. The outputs of the first set are connected to the network points through pre-set potentiometers. The successive readjustments of these voltages feeding the network are achieved by adjustment of the second set of slidewires to the voltage occurring at the network points and subsequently arranging that all these new voltages replace those previously connected to the network. The first set of slidewires is then left free for use in the following cycle.

The operation of the computer is completely automatic once the original conditions have been set up. The two hundred free slide-wires are adjusted in turn by means of a servo mechanism, and the sets of slidewires are interchanged at the end of the cycle, this process being repeated until the required number of cycles, or intervals of time, have been accomplished. At each step the value of the voltage at the network point is measured by a separate servo-mechanism, which is balanced against an accurately calibrated potentiometer. The rotation of the driving shaft of this servo is proportional to the voltage, and attached to the shaft is a digitising transducer which translates the angular position into a code, subsequently interpreted by a system of relays into decimal form (three decades). This value, together with the network point identification number, is fed to a solenoid-operated electric typewriter. The cycle number is recorded on the typewriter at the commencement of each cycle.

Facilities have been included to enable the operator to stop the machine at the end of any balancing operation, or at the end of a cycle, so that the pre-set values can be readjusted as the experiment proceeds, as is necessary, for example, in the solution of latent heat problems. The computer is constructed in three units, two similar desks each house the equipment associated with one hundred network points, and the third unit contains the main and auxiliary network supplies and control circuits. The network feed resistors are mounted on the front of the two similar desks and the network points at the rear.



A resistance network analogue computer intended for the study of heat-flow problems associated with the design of steam and gas turbines has recently begun service at Imperial College.

SPEEDY AUTOMATIC PARKING

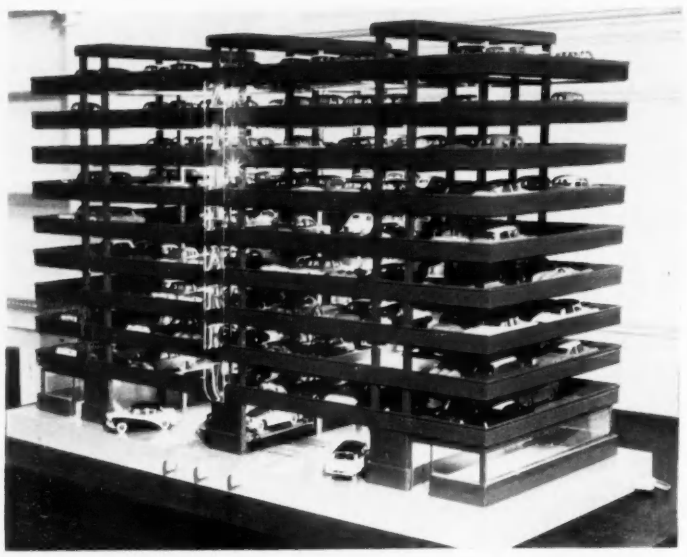
One of the problems of modern cities is that the private cars using them have to be left somewhere while the driver is attending to his business. If left in the streets they can cause obstruction, but car-parks require a considerable space. On the other hand, the ease with which traffic can flow in uncongested streets has recently been demonstrated very clearly in London and some other British cities as a result of the fuel crisis. There has been much talk consequently of banning private cars from the centre of London, and forcing people to use public transport. Such ideas have also been current in America, where New York suffers from a traffic problem that is said to be the worst in the world; but if private cars are not to be brought into the city, there must be provision made for them on the outskirts where they can be left during the day and picked up after work is finished. This again will require the construction of very large parking buildings or spaces.

Many different types of park have been considered, from the simplest row of cars in an unused street, to very complicated mechanical systems operating on many floors of a building either above or below ground. The most recent of these is the Zidpark designed by Mr. André Thaon, a Frenchman. A prototype is to be built by Taylor Woodrow Limited, at Southall, and a complete ten-storey park has been designed for New York. The illustration here is of a working model recently demonstrated in London. In the model there are three sets of two elevators serving nine parking floors. Each elevator is responsible for four spaces on each floor. The operation of parking or de-parking is entirely automatic under the control of one or two operators, each of whom can easily handle more than 100 cars. It is claimed for this system that, for a parking building having 15 levels above ground, the average parking time is about 34 seconds and the average time for reclaiming a vehicle 38 seconds.

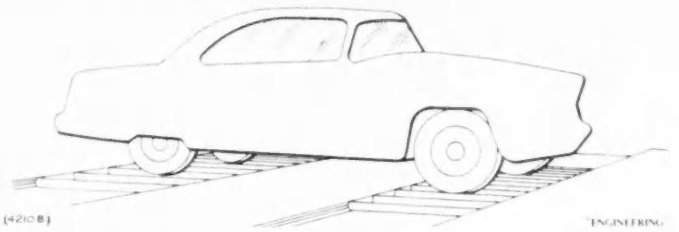
The vehicle to be parked is driven on to a conveyor as shown in the diagram, consisting of a series of tubular cross bars carried between endless chains. The driver can then get out and, if desired, can lock the vehicle which is not subsequently touched by hand until he reclaims it at the end of his stay. The operator gives him a counterfoil bearing a number, calls for the elevator, if necessary, presses the entrance button and then inserts a plug bearing a corresponding number to the counterfoil into a vacant hole on an indicator board which shows where cars are parked. The insertion of the plug starts the automatic operations. The elevator doors are opened, and the conveyor moves the car across on to the elevator. When in position it is taken up to the floor indicated on the plug board and is moved off by similar transfer conveyors, automatically started by the arrival of the elevator, on to the vacant space. To re-claim a car afterwards, the sequence is reversed, the removal of the plug from the board setting the operations into action.

Where it so happens that an inner vehicle is required first, the operator withdraws the plug corresponding to that vehicle and inserts into an empty space, whereupon the automatic operations proceed, shifting the vehicle into its new position. The withdrawal of the plug representing the required vehicle then causes the un-parking operation to proceed as before. To allow for the movement of an unwanted vehicle one free space must always be left in each section, but in a nine-storey park, like the model, it only means one empty space in 36. In a ten-storey building for a ground area of approximately 50 ft. by 120 ft., 230 cars can be parked. The system can also be adapted for use below ground level.

Owing to the fact that there is no need, as a general rule, for personnel to move among the parked cars, the space between them can be reduced to the minimum required to contain the vehicle, and with most modern cars the height can also be reduced, as the average car is not as tall as its driver. Both considerations enable a very compact building to be attained with the minimum of wasted space.



Three banks of two elevators take the cars to the different levels, as shown in this ten-storey model of the Zidpark. A prototype building is to be erected by Taylor Woodrow on a site near London.



To move the cars on and off the elevator, cross conveyors are used, and the cars are not touched by hand. Once an empty space has been selected, parking is automatically started by the insertion of a numbered plug.

BALING OUT AT 1,500 M.P.H.

A parachute-equipped "flying seat" is under development by the Lockheed Aircraft Corporation, Burbank, California, U.S.A. Incorporating aerodynamic stability and windblast protection, it is now completing full-scale model tests at the Supersonic Military Air Research Track on Hurricane Mesa, Utah, which is operated by the Coleman Engineering Company.

Basically resembling present jet-fighter ejection seats, the new seat has vertical fins extending along each side of its back to give good stability, stub-like wings 12 in. long and 8 in. wide to eliminate pitch and roll and a steel wind deflector mounted on a 4 ft. boom in front of the occupant. These flight appendages operate the instant the ejection seat separates from the cockpit.

It is believed that, with the new device, aircraft crews will be able to eject with safety at stratospheric heights and at up to twice the speed of sound—or from as low as 400 ft. at 850 m.p.h.

At Hurricane Mesa the seat is being ejected from the rim of a precipice at supersonic speeds by a rocket-propelled sled. Extensive design evaluations and wind tunnel tests, conducted with one-tenth scale models, have already been completed successfully.

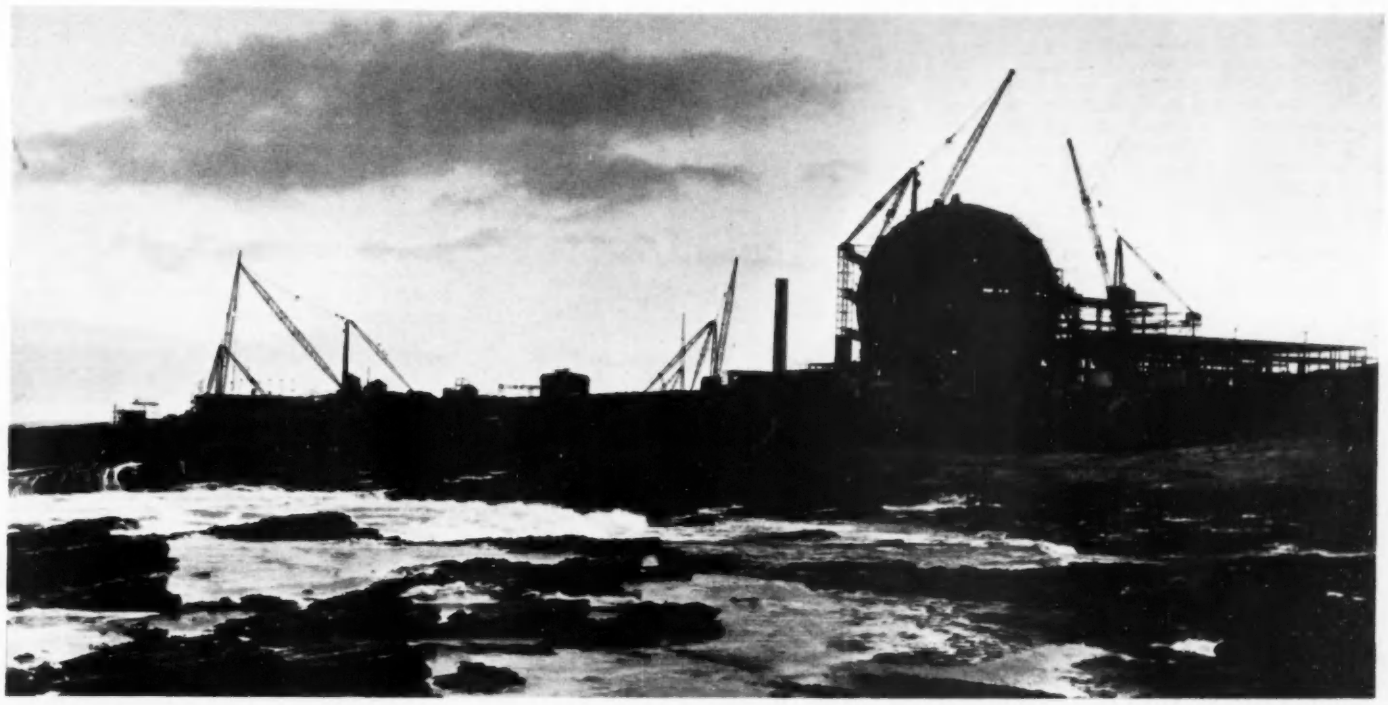
The air shield, or wind deflector, known as a skip flow generator, consists simply of an 8 in. by 5 in. steel plate on the end of a rod, which telescopes forward 4 ft. at the time of ejection; the shield forces air to "skip" and by-pass the occupant. The faster the ejection seat travels, the more efficient becomes the operation of the wind deflector in modifying air blast on the occupant and reducing decelerating loads.

With a conventional seat, fliers could be conceivably subjected to accelerations of 50*g* in a 1,500 m.p.h. bale-out at 30,000 ft., plus "tumbling" effects which could be even more hazardous than the high *g* forces. In the same situation, the new Lockheed seat, it is claimed, would reduce the load by more than 50 per cent. and eliminate the tumbling effects. Location of the centre of gravity, 4 in. further forward than in conventional seats, adds to the new system's excellent directional stability.

To separate from the aircraft and descend to earth, a crew member has only to pull up on a D-shaped ring located between his feet. The D-ring, tripping a cartridge with a 1-sec. timing delay, actuates the seat's explosive-charge catapult. During the delay, before the catapult ejects the seat along guide rails, the following pilot-safety devices are actuated: (1) Knee guards snap into position to prevent leg spreading and to counteract the effects of outward airloads. (2) Arm-support webbing comes up to prevent outward movement of the arms while allowing airloads to offset inertia forces. (3) Metal stirrups pull the feet close to the body and hold them securely until the time of man-seat separation. (4) Lateral head-supports clamp against the sides of the helmet to relieve loads on the neck.

Immediately upon clearing the aircraft the skip flow generator telescopes forward and the seat's side vanes swing open. The seat will then "fly"—completely stable—until a parachute, attached to the seat, opens automatically at a pre-determined altitude and airspeed. Normally, when the indicated airspeed is less than 300 knots and the altitude is below 15,000 ft., a combined aneroid and airspeed indicator attached to the parachute automatically controls its opening. After the parachute opens, the seat separates and falls free. If the ejection takes place at high altitudes where oxygen is limited, the early descent is made at high speed. Deceleration occurs as the seat reaches denser air. For low-speed low-altitude escapes, the parachute is opened immediately following the seat's ejection. As at high altitudes, the opening shock is taken with the crew member in the seat, then the seat is released. The new system also incorporates oxygen and communications equipment designed to withstand supersonic airblast.

Begun by Lockheed in 1955 as a company-financed research programme, development of the new escape system recently became a joint Lockheed-U.S. Air Force project. The Stanley Aviation Company, Denver, Colorado, has received a contract to build six test seats. The first production seats are scheduled to be available in mid-1957.



The majority of Britain's initial atomic power stations will be of gas-cooled graphite-moderated design, but breeder reactors will have an important part to play at a later date. As may be gathered from the illustration, work on the Dounreay fast breeder reactor in the North of Scotland is now nearing completion.

ATOMIC REVIEW

Making Ends Meet

Whatever the rate of expansion that transpires to meet the Government's revised atomic power output of 6,000 MW by 1965, it will still be possible to consider all overseas inquiries for the export of nuclear power stations. Lord Mills, the Minister of Power, made this point at the Press conference which followed his statement in the House of Lords when he announced the Government's plans, discussed briefly below. In reply to a question based on the proposed Euratom programme, he reaffirmed that orders would not be turned away; his comment that demand would develop only slowly would account for his confidence.

In making the announcement he explained that electricity demand was growing rapidly —it had increased by some two-thirds in the last seven years—and that every year we were becoming more dependent upon imported fuel, chiefly oil, which constituted a growing burden on our balance of payments. Acknowledging that home-mined coal would remain our principal source of energy for some years to come, his remarks nevertheless mean that Britain requires all the nuclear energy she can muster. The interesting question, therefore, is what constituted the limiting factors which have caused the Government to put their target at 5,000 to 6,000 MW of installed capacity by 1965?

The Target

The statement made by the Minister was extremely brief. Contained in it were the magnitude of the programme and a notice that " the supply of raw materials for nuclear generation, the acquisition of sites and the planning of the transmission network will be on a scale sufficient to bring 6,000 MW of nuclear capacity into operation by the end of 1965." It was also specified that it was intended, in addition, " to bring into commission a 150 MW nuclear station in 1963 or 1964 " in Northern Ireland.

In an explanation contained within the statement it was noted that generating capacity of 6,000 MW would save some 18 million tons of coal. No mention was made of siting but it was observed that the programme would " involve the erection of power stations and overhead transmission lines in parts of the country which have not hitherto felt the impact of the nation's requirements for electricity." An undertaking followed that the programme would be carried through with the " least possible interference " with the amenities of the countryside. That such an undertaking should have been thought necessary suggests that the Government believes that a significant part of the public is still not reconciled to the fact that Britain must have nuclear power stations almost irrespective of cost or discomfort. Indeed, one worthy member of the House of Lords sought to have the programme postponed for a generation until " nuclear power production might be achieved within some laboratory—or even within a box the size of the Dispatch Box."

Speaking at the Press conference later, Lord Mills described the programme as " flexible " and suggested that it would be necessary to build about 19 stations of the Calder Hall type. That is to say, 16 stations are to be built in addition to the three for which tenders have already been placed. This did not mean, however, that 19 different sites had to be found because " doubling-up " could and would be practised. No choice of site had yet been made, though the need of atomic power stations for vast quantities of water could only be satisfied by putting them on the coast or on estuaries. Efforts were to be made, he commented, to find at least one suitable location in Wales.

The Cost

From the figures finally elicited it was found that the estimated cost of building the proposed 19 stations was about £740 million, with a further £170 millions for the first capital charge for the uranium fuel. From these two figures it will be found that about £124 is being allowed for the installation of each kilowatt—about £20 per kilowatt less than the estimate contained in the tenders accepted by C.E.A. for the first round of stations. The gross cost of putting in electricity capacity between now and 1965 is expected to have been increased by £750 million because of the substitution of nuclear stations for conventional stations. The justification for proposing these nuclear stations was, of course, that the actual cost of generation in such stations would " fall steeply over the next few years," whereas the corresponding cost in conventional stations must inevitably rise. Lord Mills declined, however, to say when nuclear power was expected to become the cheaper. The cost of the work, £900 million, is to be met by " the Government lending the money to the C.E.A."

In reply to a question which sought to find the factors likely to limit the programme, Lord Mills listed the shortage of engineers generally and the capacity of industry to meet demands made on it. He would not, however, indicate what particular sections of industry were to be most heavily taxed by the programme. Shortages of steel, he said, were not likely to restrict the programme.

When it is considered that no serious thought has yet been given to the location of the stations, that no figures have yet been appraised for the rate of installation to be effected, and that no clear indication appears to be given showing where building capacity will be most severely strained, it will be seen that the Government's statement represents the setting of a target figure rather than a programme.

The Limitations

With the target firmly fixed, however, the manufacturing companies will be able to see the future taking shape in terms of design and production capacity. With the reactors likely all to be natural developments from Calder Hall and the three C.E.A. stations just beginning, requirements for design staff will be such that men can be released to work, if need be, on more advanced designs for future programmes. Fabrication problems will be such that, although an increase in the number of reactors to be built means a corresponding increase in materials consumed, it does not involve a comparable increase in workshop facilities or in the labour force on the shop floor.

On the civil engineering side, however, the problem is rather different. Although the superstructure may be common to several stations, the foundation problems are unlikely to be repetitive, so independent design staffs will be wanted for each station. On the construction side the labour force will increase in proportion to the number of stations tackled, both with

respect to supervision and to tradesmen. In round figures it is thought that a peak force of 1,000 men will be required on each site. The difficulty is that the number of firms having the standing and capacity to undertake the work are limited and such firms already have a full schedule of major works for some years to come, including the very material contribution which they can make to the exports of the country by doing work overseas. On the other hand, there is some slackness among the smaller firms who normally tender to local authorities; one problem will be efficiently to mobilise the staff tied up in these smaller firms.

Euratom Exports

From the point of view of exporting reactors, the target offers little difficulty other than that of finding the necessary materials—and there the prospective buyer might be in a strong position to supply his own materials. As already suggested, manufacturing facilities will not be greatly stretched by winning tenders from overseas, and designs would be largely based on existing projects; the civil engineering work involved would most likely be undertaken by local contractors and would not therefore affect work in Britain.

As was made known during the visit to this country of the " three wise men " of Euratom—M. Louis Armand (France), Herr Franz Etzel (Germany), and Professor Francesco Giordani (Italy)—the final draft of the six-country treaty is ready for signature and it is expected that their plan for nuclear energy on the Continent will be announced in about a month's time. (The treaty provides for a six-country community—France, Germany, Italy, Belgium, Holland and Luxembourg—mutually subscribing to the peaceful use of atomic energy. The agency to be set up will plan and erect the stations required and will be the legal owner of all and any fissile material issued to the users.)

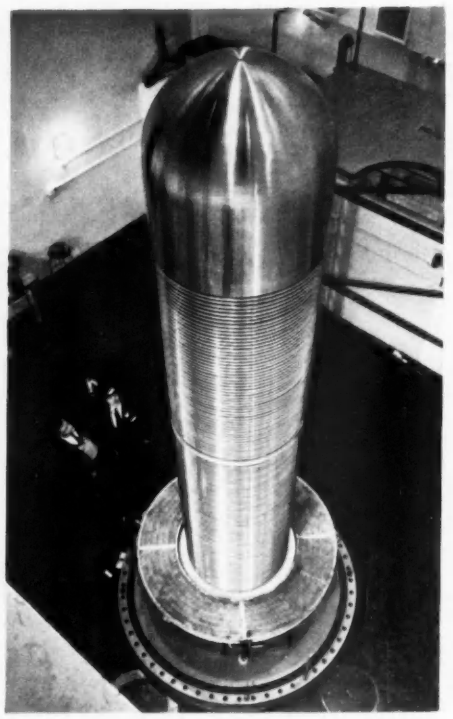
While they were here the Euratom representatives, besides pressing their suggestion for Britain to join their organisation—" no door would be closed " to such co-operation—persuaded the Government, through the U.K.A.E.A., to agree to send a task force on to the Continent to advise on their programme. At a Press conference which they gave in London they indicated that what they had seen here suggested that it was Britain, rather than the United States, which could be their greatest help. Britain, they said, had problems more nearly those of Europe than did the United States, where conventional fuels were still relatively cheap; moreover, Britain was nearer to building nuclear stations economically than was the United States, where research had been more on a long-term basis suited to the particular requirements there. Adding that they had seen representatives of the principal contracting groups already established in Britain, they made it clear that British firms were expected to tender for the stations they proposed to build and gave the impression that such bids stood a high chance —in as much as such things may be forecast by responsible officers—of being successful.

General Notes

NERO Goes Critical

" NERO," a new experimental low energy reactor, is now operating at the Atomic Energy Establishment, Harwell. It became critical for the first time at 7.45 p.m. on February 23, and its experimental programme is now beginning.

The reactor will be used to investigate the physics design problems associated with the more advanced types of graphite-moderated power reactors now under study by the Authority. The reactor consists of a graphite stack, which can be varied in size up to a cylinder of about 14 ft. in diameter by 10 ft. high, within a 2 ft. thick concrete biological shield. Fuel elements of differing types may be arranged within the graphite stack in any one of a number of possible lattice patterns. The restacking of the graphite to permit a change in the fuel element arrangement can be done in a few days. Control is achieved by two vertical cadmium control rods which can be moved into the graphite stack in a similar manner. The maximum thermal neutron flux is about 10^8 neutrons per sq. cm. per sec. and the heat output is restricted to less than a hundred watts.



Six megavolt Van de Graaff generator at Aldermaston. The outer casing, which usually keeps the whole machine under pressure in order to reduce corona loss and inhibit breakdown, has been removed for illustration purposes.

The reactor will at first be used to check calculations on the effect of separating the fissile content of the fuel (e.g., U235 or Pu239) from the fertile content (e.g., U238). Information of this kind is of great importance for the design of reactors in which nuclear fuel (e.g., plutonium) may be recycled through the reactor. Another application of the reactor is to investigate problems associated with the design study of a sodium-cooled graphite-moderated reactor. For this reason the name NERO is derived from the phrase " Na (chemical symbol for sodium) experimental reactor." The " O " is added to indicate that it is a zero energy (i.e., low energy) reactor. It is expected that the feasibility study on the sodium graphite system will be completed by the end of the year.

U.S. Nuclear Power Plants

Twelve American utilities in the Ohio River Valley are reported to have joined together to build two nuclear reactors, one a prototype 13 MW plant (probably a heat rating since it is unlikely that the reactor will be connected to a turbine), and the other a 200 MW station. No details of the reactors have yet been published but it is expected that the entire project will be completed by 1962, at a cost probably not exceeding 31 million dol. The chairman of the twelve-company committee is Mr. Philip Sporn, President of the American Gas and Electric Company, one of the participants. Mr. Sporn, who has played a considerable part in the improvement of conventional station efficiencies, has stated that attention will be given to reactors without inherent limitations on temperature and pressure, and that temperatures in the region of 1,000 deg. F. (540 deg. C.) are envisaged.

It has also been announced that four Pacific Northwest utilities have purchased a 9,000 acre site near Hanford, Washington, for nuclear power purposes. Mr. Paul B. McKee, president of the Pacific Power and Light Company, one of the four co-operating firms, said that considerable reductions in the cost of atomic power could be foreseen and that it was necessary to be prepared. It is significant that the Pacific Northwest is an area which has large hydro-electric resources, and that the Ohio River Valley—where the first project is to be undertaken—includes a major coal-producing area. Existing United States nuclear power projects (in excess of 50 MW) were tabled on page 762 in Atomic Review last December 14.

Van de Graaff Generator

Shown in the illustration on the left is the six million volt Van de Graaff electrostatic generator at the Atomic Weapons Research Establishment, Aldermaston. The final potential of the top dome is used to accelerate beams of protons or deutrons to high energies. A feature of the machine is the accuracy with which the final potential may be controlled—1 kV in 6,000 kV. Consequently, constant-energy beams may be produced and used for detailed investigation of nuclear energy levels. A continuous non-conducting belt carries an electrostatic charge from the bottom of the machine to the top dome where it accumulates and builds up a potential. The value of the final potential may be controlled by adjustment of the potential at which charge is sprayed on at the bottom.

Boron-10

Increased quantities of the isotope boron-10 are being made available by the United States Atomic Energy Commission for civilian use. Since boron-10 has the nuclear property of readily absorbing neutrons without itself becoming radioactive, it is particularly suitable for use in nuclear reactor shielding and control mechanisms, and also can be employed in radiation-measurement instruments.

Boron exists in nature as a mixture of two isotopes: the isotope boron-10 constitutes 19·8 per cent. of natural boron, with the remainder being the isotope boron-11, which does not readily absorb neutrons. Therefore, in many applications it is desirable to separate the boron-10 from boron-11. In most instances the separated boron-10 or, more specifically, material enriched in the boron-10 isotope, is then processed into metal. Some Commission projects are already using enriched boron. However, non-Government uses have in the past been very limited, since only gram quantities have been supplied. In view of the growing industrial utilisation of atomic energy and the need for enriched boron-10, the Commission will now make kilogram quantities of this material available for non-Government uses.

Enriched boron-10 in metal form and also in some chemical forms (boron trifluoride-dimethyl-ether complex and potassium fluoborate) is produced in a Government-owned plant near Niagara Falls, New York. The plant started operation in June, 1954. The recently declassified process used at this plant for the production of enriched boron-10 metal is conducted in two phases. The first phase brings about the separation of the isotopes by an exchange method which takes place in distillation equipment somewhat similar to that used in the petroleum industry (see Atomic Review, January 4). At the time this separation takes place, the boron is in the form of the boron trifluoride-dimethylether complex. After the enrichment has been carried out, potassium fluoborate is precipitated from the liquid complex. Boron metal is then produced from this compound by electrolysis. The plant is capable of producing enriched boron at assays ranging from 30 per cent. to 95 per cent. boron-10.

Base Load and Nuclear Power Stations

Two weeks ago we referred to a lecture by Mr. P. J. Squire on nuclear generation. After the lecture Mr. Squire discussed in greater detail

the subject of base load, with particular reference to nuclear power stations. The substance of his remarks is given here.

Any variation of station efficiencies with load factor for nuclear and conventional plants would have little influence on the factor of operation of the nuclear plants, owing to the large differential in fuel costs. The relative capital and operating costs of the various types of plant are, of course, taken into consideration when the plant programmes are planned, but once the selection of plant has been made the load factor of operation in practice should be decided entirely by the relative fuel costs per unit generated. With new manufacturing equipment, such as machine tools, a high load factor can usually be assured by energetic sales policy, so recovering quickly the capital cost. But in electricity supply the demand from hour to hour is determined by the consumers and any material improvement in the shape of the overall load curve is a slow process which must be regarded on a long-term basis. Plant of sufficient capacity must be purchased to cover the maximum requirements, and once this is installed the associated capital charges have been irrevocably incurred, but it is obviously desirable to load the plants to give the greatest fuel cost economy and this will be achieved by loading more highly those plants with the lowest fuel costs—in other words, nuclear stations.

Courses and Conferences

The next Nuclear Physics Conference of the Physical Society, 1 Lowther-gardens, London, S.W.7, is to be held at the University of Manchester and organised by Professor S. Devons, F.R.S. It will be a two-day meeting and take place during the period July 15 to 20, 1957.

The University of Nottingham is planning a residential course on nuclear engineering to be held there from September 15 to 21, 1957. The course will be directed at engineers new to the field and requiring a general outline rather than a detailed study. Many eminent authorities will be taking part.

Last week in a Weekly Survey note (page 294) we drew attention to the one year post-graduate course in nuclear power to be held at Imperial College, London under Professor J. M. Kay. A summary of the courses appears below.

Applied Nuclear Physics.—Nuclear particles; radiation; stability of nuclei; radioactive decay; reaction of particles, protons and neutrons with nuclei; neutron capture; neutron scattering; fission; thermonuclear reactions.

Nuclear Reactor Theory.—Neutron reactions and nuclear cross sections; fast reactors and thermal reactors, thermal neutron chain reactions; neutron diffusion theory; critical size calculations; two-group theory; calculation of lattice constants; change of reactivity; transient conditions; control of nuclear reactors.

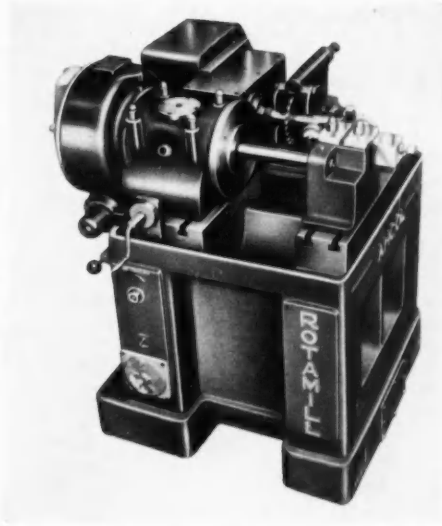
Nuclear Fuel Technology.—Physical and chemical properties of uranium and thorium; extraction from ores, purification and reduction; fabrication of fuel elements; handling of irradiated fuel; chemical separation; disposal of fission products.

Design and Construction of Nuclear Reactors.—Design of fuel elements; choice of moderator, coolant and canning material; heat release and heat transfer; design of the coolant circuit, pumps and compressors; charging and discharging of fuel elements; special problems with graphite moderated reactors; special problems with water moderated reactors; other types of reactor; pressure vessel design; shielding.

Chemical and Biological Effects of Radiation.—Effects of neutrons, particles, and of radiation on living cells; safety considerations; shielding.

Dark Towers?

It is evident from recent news that the modern Childe Roland regards the atomic power station as a dark tower—dark towers are not of course to be confused with Satanic Mills. Clearly the students from Manchester College of Science and Technology who raided Calder B were neither spies nor Luddites but simple honest fellows engaged on an heroic quest for some intangible reward (appointments with firms of publicists perhaps?). It is not surprising therefore that Sir John Cockcroft has appealed to architects to fit nuclear power stations into the landscape, "just as castles and forts had been in Saxon times." True, the power-station need no more disfigure the countryside than the hydro-electric scheme, but Sir John's intention—like the Saxon's—is surely as much protective as aesthetic. His purpose cannot be simply to disguise Berkeley and Bradwell (like certain Victorian water works) as Cistercian monasteries, but to conceal them from marauding Percevals.



Specially designed for milling slots and flats on components suitable for automatic clamping, the Ahcol Rotamill can also be used with manual clamping fixtures if necessary.

SEMI-AUTOMATIC MILLING OF SLOTS AND FLATS

Continuous Rotary Feed

The Ahcol Rotamill, marketed by Dowding and Doll, Limited, 346 Kensington High-street, London, W.14, is designed for semi-automatic milling of slots, flats and faces, the components being fed to the milling cutters by means of a continuously rotating head. It is particularly suited for use with workpieces which are of a type suitable for automatic clamping, but can be adapted for dealing with more awkwardly-shaped components, by the fitting of two or more simplified fixtures suitable for manual clamping.

The cutter arbor, which is roller-bearing mounted, is driven by a 5 h.p. electric motor, and can be run at any one of four speeds, 132, 211, 330, or 528 r.p.m., by means of detachable pulleys. Additional pulleys can be provided for other speeds. Cutters up to 6 in. diameter can be accommodated, the maximum width for gang cutters being 6 in. The work head, which has an integral faceplate, is driven through a gearbox and a worm and wheel from the cutter head. By means of the gearbox, 14 rates of feed are obtainable for each spindle speed. A 5¼ in. diameter spigot is provided on the faceplate for locating fixtures, and there are also tapped holes for fixture holding bolts. The workhead spindle bore has a No. 3 taper, and an extension arbor and outboard bearing bracket can be provided for carrying wide fixtures if required. A detachable T-slotted faceplate can also be supplied for bolting to the spindle faceplate. Adjustment of the work head relative to the cutters is by screw and handle, a graduated collar giving readings of 0·001 in. A pressure-pad bracket, complete with springs and tension adjustment is available for applying top pressure to workpieces when clamping automatically.

The machine is provided with "start" and "stop" push-buttons which control the main motor driving the cutter head. A clutch in the work head drive is knob-controlled from the front of the machine. As an extra fitting the machine can have a fast traverse, equivalent to 565 in. per minute on a 12 in. periphery, to the work head, and when this is fitted a switch marked "hand" and "auto" is provided. When it is set to "hand," the switch enables the operator to engage the fast traverse after loading the fixture; when it is set to "auto," the fast traverse engages automatically. In both cases the fast traverse is disengaged automatically at the commencement of the cut. Setting collars and trip pins make it possible for the angular spacing of the fast traverse to be adjusted as required.

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AIR TRANSPORT ON THE SCREEN

At the suggestion of the International Air Transport Association—the scheduled airlines association—the film unit of the Shell Petroleum Company have produced a 16 mm. sound film in Eastman Colour, "Song of the Clouds," the main theme of which is air transport in the service of mankind. The film, which has a running time of 36 minutes, was made with the co-operation of IATA and of ICAO, the International Civil Aviation Organisation affiliated to the United Nations, which is responsible for setting up international aviation standards and facilities. Help was given by Shell Group associates in more than 36 countries and by more than 70 airlines. Particular emphasis is laid upon the way in which air transport is serving people living in areas practically impenetrable by other means of transport; and, in addition to wonderful panoramas of the mountains, arctic wastes, and dense jungle, over which the air liners fly, the film provides a glimpse of the extensive international organisation that lies behind the smooth operation of commercial flying.

At a private showing of "Song of the Clouds," the vast progress in commercial air transport and airport and navigational facilities during the last 20 years was brought out by the showing of another 16 mm. Shell sound film, "Airports," made at Croydon in 1935 when Croydon Airport was London's international airport and a source of pride to British aviation.

Both films are available on loan to responsible organisations from the Petroleum Films Bureau, 29 New Bond-street, London, W.1.

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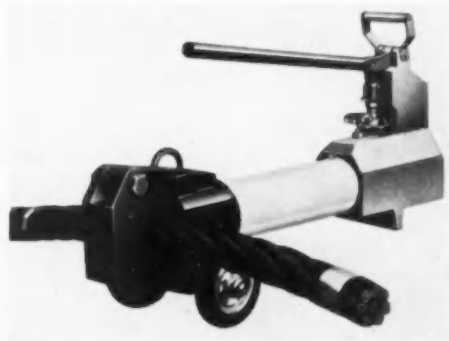
PORTABLE HYDRAULIC SHEAR

A portable shear, hydraulically operated, for cutting rod, wire ropes, cables or chains, has been produced by the Copelaw Engineering Company, Limited, Mowden Hall, Darlington, Co. Durham. The largest model of the "Carricut" is shown in the illustration. The machine is completely self-contained in that hydraulic pressure is applied by a hand pump, and no external source of power is required. The smallest size, which will cut rod up to ⅞ in. in diameter, weighs only 20 lb., while the one illustrated, which will cut wire rope up to 2 in. in diameter or electric cables up to 3¼ in. in diameter, weighs 209 lb. At the moment five models are made. An alternative version has a foot pump instead of a hand lever, which is connected by flexible hose to the shear, thus allowing remote operation.



With its own hand operated pump, the "Carricut" hydraulic shear is portable; this model can cut wire ropes up to 2 in. in diameter.

TYPED FIGURES TRANSLATED INTO COMPUTER CODE

High-Speed Reading by Electric Automaton

The results from a computer may be obtained with negligible delay by the use of an electric typewriter. However, the reverse process at the input, the automatic translation of typescript into the code required by a computer, is in practice a most difficult problem. The non-automatic solution, which is essentially slow, is to have a typist "re-type" the material to be processed, using a machine that punches code symbols on tape. The crucial operation is the recognition by the typist of a printed or written character as the character its writer intended it to be. Discrimination—the recognition of the class to which a given object or symbol belongs—is one of the most fundamental acts performed by man and it is the most difficult to imitate with a machine. Thus the electronic reading automaton (ERA) produced by Solartron Electronic Business Machines, Limited, Goodwyns-place, Dorking, Surrey, is a significant development.

The need for such a machine has been felt for some time. Computers originally designed for complex mathematical problems concerning a relatively small amount of information were not suitable for immediate application to business problems. The characteristics of such problems are large amounts of material that require simple and repetitive arithmetical calculations and sorting. A computer working on business problems would take so little time on individual calculations that the input speeds necessary are very high, preparation being the chief delay.

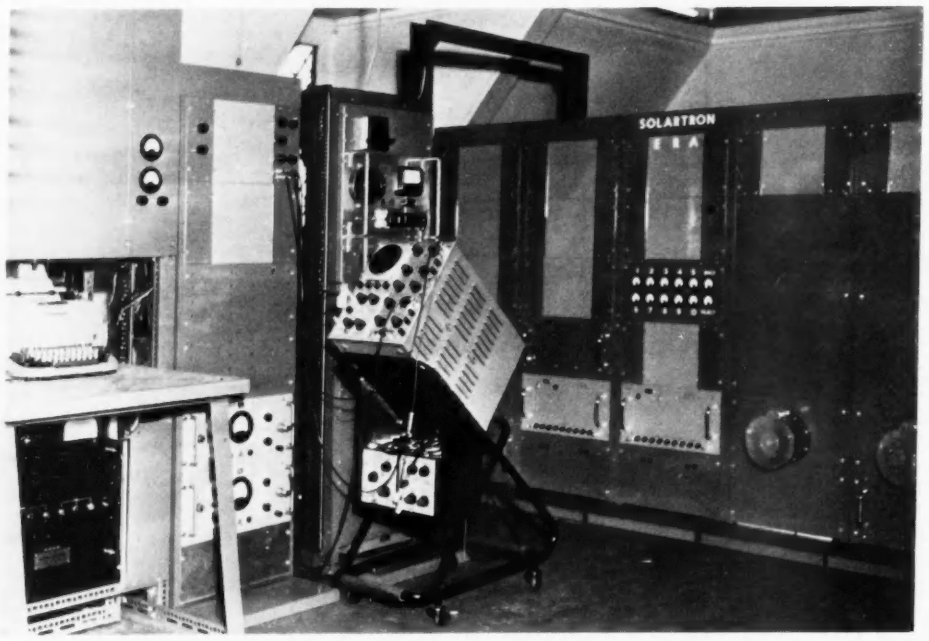


Fig. 1 The pilot production model of the Solartron electronic reading automaton. The flying-spot scanner is located to the left, over the electric typewriter.

This machine, produced for use in large business concerns, reads printed numbers. Typical inputs that can be accommodated are tally rolls, from cash registers, microfilm records, cheques, invoices, and clock-cards. Outputs are similarly diverse. Punched cards, punched or magnetic tape, may be generated; the results may be fed straight into a computer; or the original documents may be sorted. Unlike previous machines, it does not require a special type face or a blemish-free document, and so can find immediate application. Magnetic inks are quite unnecessary. The pilot model reads figures at a rate of 120 per second. The production model will operate at about 200 to 300 per second. On the basis of these figures the makers claim that the machine could do the work of 150 to 300 operators, who would cost up to £300,000 per year. The ERA will cost between £20,000 and £50,000, according to the input facilities required. Consequently, when used by a large concern it can pay for itself within a few months. The speed of operation presents a solution to the banks' clearing-house problem (ENGINEERING, March 8, 1957, page 295) without the necessity of using special writing materials.

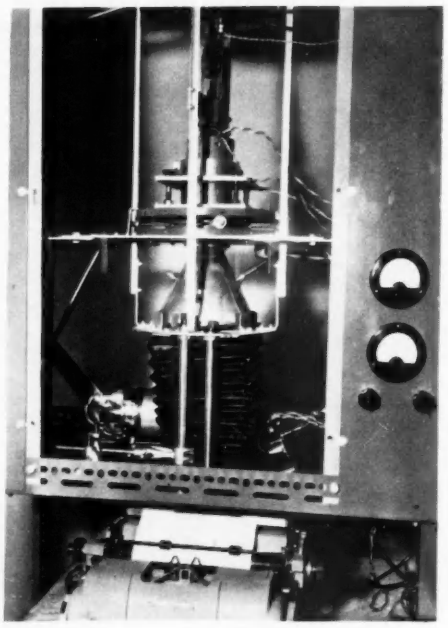


Fig. 2 Close-up of the flying-spot scanner. The input is provided by an electric typewriter in order to give statistical information on the behaviour of the equipment.

A feature of the ERA is the manner in which information is used. In the course of a recent talk given at the Institution of Electrical Engineers, Dr. E. C. Cherry emphasised the value that a better understanding of human perception would have for the electronic engineer. Particularly interesting is the compression of information that occurs. The eye or ear collects an enormous amount of information from its environment but only the smallest fraction is used for decision making. Similar behaviour is shown by the ERA. Although the machine does not make the decisions—that operation being the job of the computer that it might feed—there is a large difference between the amount of information taken in and that given out. The unit of information is the "bit." One bit is the amount of information that tells which of two equally likely possibilities has been chosen, e.g., whether a coin has fallen as a head or tail. To recognise an individual figure the ERA uses 100 bits, but theoretically this operation requires less than four bits. Thus a large amount of redundant information is present. For whereas four bits are sufficient to distinguish any one of 16 characters, 100 bits will distinguish one out of 2^{100} characters, or will be enough to distinguish each separate atom in a ten yard solid cube. Redundancy is a useful tool to the communication engineer. A single mistake in a message that contains no redundant information will render the message completely useless and probably misleading. As the redundancy is increased the effect of errors decreases. It is this principle that is used in the ERA.

The errors that are likely to arise are due to the nature of the material that has to be read. Often figures are distorted, defective, smudged or displaced. Specks of dirt or grimy folds in paper can be further sources of misleading information. By extracting much more information than is necessary for theoretically perfect print, the effect of such imperfections is made negligib e.

Documents can be read while stationary or moving, and the machine can be programmed to read various parts of a document without mechanical movement of the document. To read a character the machine scans the square space that should contain the character with a spot of light. The square is divided into ten vertical columns and the light spot is flicked down each in turn, each column being itself divided into ten. Thus each figure is divided into 100 areas. The reflected light from the surface of the document is focussed on to a photo cell which will generate a signal proportional to the amount of light reflected into it. Thus if one area contains no ink the reflection will be good and the photo cell output high. If the element of area contains ink the reflection will be bad and little or no signal will appear from the photo cell. The output from the photo cell is amplified and limited. The latter operation changes the character of the pulses from the cell so that they indicate an elementry area to be either all black or all white. The error introduced by ignoring partly inked squares is not significant owing to the high degree of redundancy present. The 100 signals telling which parts of the figure are black or white are then passed into a logical network that decides from this information what the figure is.

The logical network consists of components that may assume either of two states of conductivity and wired up for "and/or logic." The components in this system are germanium diodes and the two states are conducting and non-conducting. If the component changes its state when all of several inputs to it are present then it exhibits "and logic." If only one of several inputs is necessary to cause the change, "or logic" is exhibited. The two states can be made to represent "yes" or "no." Thus a typical operation performed by this network would be: "If black is (either in 12 and 13 or in 32 and 33) *and* is in 22 and 23, but is not in 37 or 38, the character is 4." In practice the argument would be more complex. The redundancy will permit slight variations in type face to be read by the

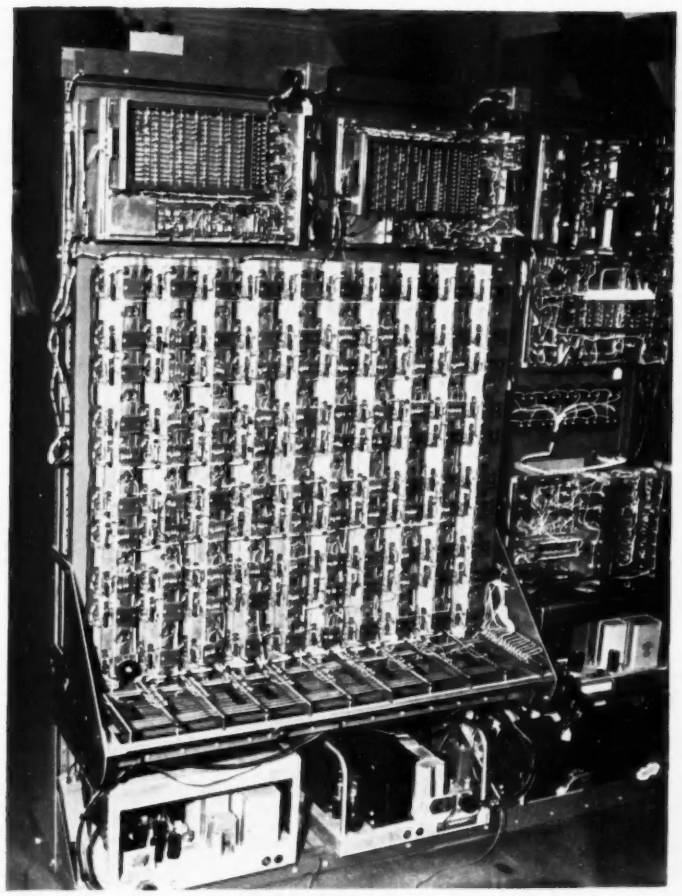
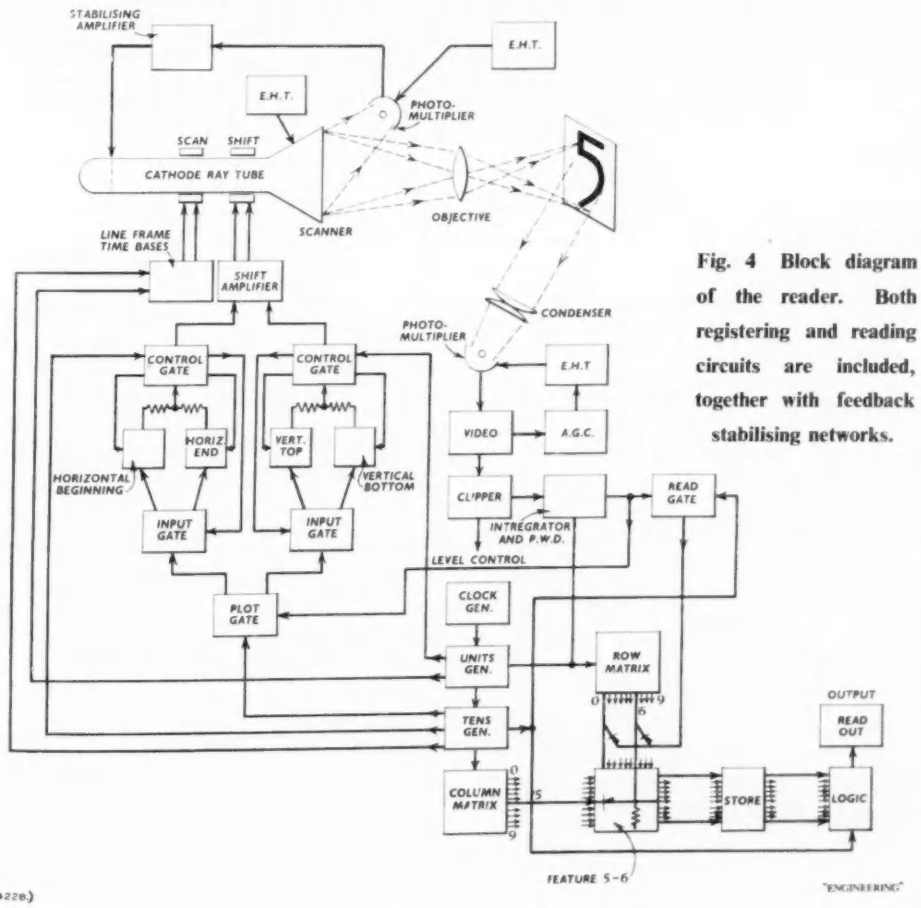


Fig. 3 Part of the logic circuit. The construction allows maximum access for adjustment; production models will be more compact, possibly occupying one-third of the present space.

same machine: a pencilled imitation of a type face has been read by the pilot model. However widely different founts will require different logical networks. Fundamentally there is no reason why the machine should not be extended to read texts, whether they are printed or written, but there is little likelihood of there being sufficient demand to make their manufacture an economic proposition. One field of application would be in the machine translation of language—a situation similar to the business one, that is, a computer performing simple operations and consequently demanding a high input rate.

A block diagram of the ERA appears in Fig. 4. A flying spot scanner is used to produce the spot pattern. A beam of electrons in a cathode-ray tube forms a bright spot on the face of the tube. Voltages applied to the deflection plates can flick the electron beam, and therefore the spot, in to each of its 100 positions at a far greater speed than is possible with a mechanical system. Lenses then focus the reflection of the spot on to the photomultiplier cell.



(4228)

Fig. 4 Block diagram of the reader. Both registering and reading circuits are included, together with feedback stabilising networks.

Some misalignment of the typed figure can be compensated for in the "and/or logic" but where severe misalignment may occur each figure is scanned twice: once to correct alignment, and once to read. In the first scan the positions of the first and last columns that have any black in them are counted, the difference halved and the result used to determine the amount of shift necessary horizontally. A similar process is carried out vertically. By applying correcting voltages, proportional to the shifts required, to the deflection mechanism in the cathode-ray tube, the raster—the pattern followed by the light spot—can be centred and aligned over the figure. This operation, called "registering," to distinguish it from "recognising," uses twice as fine a raster as for recognising. The various operations throughout the machine are synchronised by an electronic "clock" that produces a basic pulse time of 2 microseconds. Multiples of this basic time control the raster. A feature period lasts for 8 microseconds and it is followed by a blank period of 4 microseconds.

The output from the machine appears as a pulse on one of ten wires—each wire corresponding to a figure from 0 to 9. Such pulses can operate a keyboard or sorter directly. For feeding a computer directly, the numerals can be stored each in binary form in a temporary store, which is then gated serially by clock-pulses from the computer. It is possible to synchronise the clock in the reader with that of the computer and so make the read time a sub-multiple of the computer's clock time. To correct for progressive "creep" in reading a long document such as a paper roll, the smoothed component of the correction output is available as a servo signal.

It is interesting to speculate as to what light the structure of ERA throws on the mechanism of human perception. The first point that arises in any comparison is the outstanding superiority of the eye. The eye can recognise an extremely wide variety of different letters irrespective of variations in style, surroundings, or perspective. However, recognition of characters is a process that is learnt, and the learning process could be considered as similar to the setting up of a logic network. The part played by logic is brought out by the experience of blind persons who suddenly are able to see. They are conscious at first of nothing but a jumbled array of colours and it might be two years before a simple shape such as a square is recognisable, and then only by the conscious application of logic, i.e., counting the corners. It would seem that Dr. Cherry's remarks on the value of co-operation between the experimental psychologist and the electronic engineer have been given fresh emphasis by this new development.

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ELECTRON MICROSCOPY

Summer School at Cambridge

A summer school in "The Use of Electrons in the Examination of Metals" will be held in the Departments of Metallurgy and Physics, University of Cambridge, from July 9 to 20. Simultaneously with advances in the design of high-resolution electron microscopes and in the specimen techniques used for examining metals, new electron optical methods have been developed for examining metals. These new electron optical methods include scanning electron microscopy, selected area diffraction, X-ray microscopy and X-ray micro-analysis. At the summer school, the theory and practice of these new techniques will be described.

Apart from the main lectures for which some knowledge of electron microscopy will be assumed, there will be a series of elementary lectures and practical demonstrations for those coming new to this field of research.

The fee for the course is £25 and accommodation will be in Pembroke College, Cambridge. Further information and application forms may be obtained from the secretary, The Board of Extra-Mural Studies, Stuart House, Mill-lane, Cambridge. Completed application forms should be returned before May 15.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"The Theory and Practice of Plant Maintenance, with Reference to Planning," by H. V. Mather. London National Lecture. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Mar. 19, 6.30 p.m.

YORK
Co-ordination Between Lighting and Decoration," by Raymond Pye. York Branch. Royal Station Hotel, York. Tues., Mar. 19, 7.30 p.m.

British Institute of Management

LONDON
"Management Problems Involved in Reorganising Keith Prowse and Co. Ltd.," by Peter Cadbury. Thurs., Mar. 21, 6.30 p.m.

Building Centre

LONDON
Film "Case Fire," exhibited by Hickson's Timber Impregnation Co. (G.B.), Ltd. Wed., Mar. 20, 12.45 p.m.

Chemical Society

BRISTOL
"Terylene," by Dr. P. T. Barrett. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Mar. 21, 7 p.m.

Diesel Engineers and Users Association

LONDON
"Fast-Running Light-Weight Engines for Marine Duties," by E. Chatterton. Caxton Hall, off Victoria-street, S.W.1. Thurs., Mar. 21, 2.30 p.m.

Illuminating Engineering Society

BIRMINGHAM
"Street Lighting from a City Engineer's Point of View," by Granville Berry. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Mar. 22, 6 p.m.

MANCHESTER
"Recent Developments in Lighting Techniques," by J. Jansen. Manchester Centre. Offices of the North Western Electricity Board, Town Hall, Manchester. Thurs., Mar. 21, 6 p.m.

Incorporated Plant Engineers

LONDON
"Pumping Plant in the Field," by H. P. S. Paish. College of Preceptors, Bloomsbury-square, W.C.1. Thurs., Mar. 21, 7 p.m.

BIRMINGHAM
Annual General Meeting. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Mar. 22, 7.30 p.m.

BLACKBURN
Annual General Meeting. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Mar. 21, 7.30 p.m.

BRISTOL
Annual General Meeting and Film Evening. Western Branch. Grand Hotel, Bristol. Tues., Mar. 19, 7.15 p.m.

NOTTINGHAM
Annual General Meeting. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Mar. 20, 7 p.m.

ROCHESTER
"Optics as an Aid to the Engineer," by John R. Adams. Kent Branch. Kings Head Hotel, High-street, Rochester. Wed., Mar. 20, 7 p.m.

Institute of Marine Engineers

LONDON
"Gas Turbines," by W. J. R. Stocks. Student Lecture. Mon., Mar. 18, 6.30 p.m.*
Annual General Meeting and Discussion on "A Comparison of the Training of Sea-Going Engineers in Other Countries." Education Group. Tues., Mar. 19, 5.30 p.m.*

CARDIFF
Films on "Technicalities of the Petroleum Industry." South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Mon., Mar. 18, 7 p.m.

LEEDS
"Visual Observations of Stresses," by Dr. J. Ward. Kingston-upon-Hull and East Midlands Section. Hotel Metropole, Leeds. Thurs., Mar. 21, 7.30 p.m.

Institute of Marine Engineers and Institution of Naval Architects

SOUTHAMPTON
"Developments in Marine Electrical Installations, with Particular Reference to Alternating-Current Supply," by A. N. Savage. Southern Joint Branch. Southampton Technical College, Southampton. Tues., Mar. 19, 7.30 p.m.

Institute of Physics

LONDON
"Semi-Conductors and the New Electronics," by Dr. R. A. Smith. London and Home Counties Branch. Wed., Mar. 20, 6.30 p.m.*

Institute of Road Transport Engineers

LONDON
"Design and Construction of a Modern Goods-Carrying Vehicle," by A. S. C. Marks. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Mar. 21, 6.30 p.m.

LEEDS
"My Experiences at Motor Rallies and Races," by Ian Appleyard. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds. Thurs., Mar. 21, 7.30 p.m.

Institution of British Agricultural Engineers

LINCOLN
"Development of Power Frame Tractors," by H. E. Ashfield. East Midlands Centre. Agriculture House, Lincoln. Wed., Mar 20, 7 p.m.

Institution of Chemical Engineers

LEEDS
"A Study of the Motion of the Solid Phase in Liquid Fluidised Beds," by N. L. Franklin and D. Handley. North Western Branch. The University, Leeds. Wed., Mar. 20, 7 p.m.

Institution of Civil Engineers

LONDON
"A Major Power Plan for Yukon River Waters in the Canadian Northwest," by J. M. Wardle. Tues., Mar. 19, 5.30 p.m.*

MANCHESTER
"Soil Mechanics in Municipal Engineering," by R. G. Ashworth. North Western Association. Engineers' Club, Albert-square, Manchester. Thurs., Mar. 21, 6.30 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "What is Limiting the Application of Servo Mechanisms in the Electrical Industry?" opened by C. Ryder. Mon., Mar. 18, 5.30 p.m.*
"Recent Developments in X-Ray and Electron Microscopy with Some Applications to Radio and Electronics," by Dr. V. E. Cosslett and C. W. Oatley. Radio and Telecommunication Section. Wed., Mar. 20, 5.30 p.m.*
"A Cyclotron for Medical Research," by J. W. Gallop and others. Thurs., Mar. 21, 5.30 p.m.*

CHESTER
"Highland Water Power: The Developments of the North of Scotland Hydro-Electric Board," by the late T. Lawrie. Joint meeting of the Mersey and North Wales Centre and the North Western Centre. Town Hall, Chester. Mon., Mar. 18, 6.30 p.m.

NOTTINGHAM
"The Control and Instrumentation of a Nuclear Reactor," by A. B. Gillespie. East Midland Centre. College of Arts and Crafts, Waverley-street, Nottingham. Tues., Mar. 19, 6.30 p.m.

Institution of Engineering Designers

LONDON
"Some Influences of Equipment Installations and Systems on Aircraft Designs," by C. F. Joy. Tues., Mar. 19, 6.45 p.m.

Institution of Engineers and Shipbuilders in Scotland

GREENOCK
"Techniques for Hydraulic Machinery Research," by Dr. S. P. Hutton. Joint meeting with the Greenock Association of Engineers and Shipbuilders. The Lorne, 69 West Blackhall-street, Greenock. Tues., Mar. 19, 7.30 p.m.

Institution of Heating and Ventilating Engineers

LEEDS
Annual General Meeting. "Geo-Thermal Heating in New Zealand," by G. M. Hoyle. Yorkshire Branch. Griffin Hotel, Leeds. Wed., Mar. 20, 7.30 p.m.

Institution of Highway Engineers

DURHAM
Discussion on "Surveying: Including the Use of Instruments and Drawing Office Materials." North East Branch. The University, Palace Green, Durham City. Fri., Mar. 22, 7 p.m.

Institution of Locomotive Engineers

LONDON
Annual General Meeting. "Unification of Freight Vehicles on Oversea Railways," by A. Campbell. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Mar. 20, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "The Future of Streamlined Casings for Motor Cycles." Automobile Division. Tues., Mar. 19, 6.45 p.m.*
Annual General Meeting. Fri., Mar. 22, 6 p.m.*

Institution of Mining and Metallurgy

LONDON
"Separation of Uranium and Copper During the Acid Pressure Leaching of Sulphidic Uranium Alloys," by J. Halpern and F. A. Forward; and "Hydrometallurgical Processes at High Temperatures," by F. A. Forward and J. Halpern. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Mar. 21, 5 p.m.*

Institution of Production Engineers

LONDON
Annual General Meeting. "Galvanising," by L. F. Chambers; and "Metal Spraying," by G. A. Curson. London Section. Royal Empire Society, Craven-street, Strand, W.C.2. Thurs., Mar. 21, 7 p.m.

BIRMINGHAM
Annual General Meeting. "Modern Techniques in Die Casting Practice," by J. Bailey. Birmingham Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Mar. 20, 7 p.m.

GLASGOW
"Ferrous Die Casting," by C. A. Payne. Glasgow Section. Institution of Engineers and Shipbuilders, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Mar. 21, 7.30 p.m.

SHEFFIELD
George Bray Memorial Lecture: "Scope for Operational Research in Industry," by Stafford Beer. Sheffield Section. City Memorial Hall, Sheffield. Mon., Mar. 18, 6.30 p.m.

Institution of Railway Signal Engineers

LONDON
"Automatic Operation of Marshalling Yards," by D. C. Webb. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Mar. 19, 6 p.m.*

Institution of the Rubber Industry

LIVERPOOL
"Extruders and Extruding," by A. Crowther. Merseyside Section. 24 Hatton-garden, Liverpool. Tues., Mar. 19, 7.15 p.m.

Institution of Structural Engineers

MANCHESTER
"Some Aspects of Research Work on Prestressed Concrete," by Professor R. H. Evans. Lancashire and Cheshire Branch. College of Technology, Manchester. Tues., Mar. 19, 6.30 p.m.*

Junior Institution of Engineers

LONDON
"Gas Chromatography," by H. W. D. Hughes. Fri., Mar. 22, 7 p.m.*

Liverpool Metallurgical Society

LIVERPOOL
"Steels at Elevated Temperatures," by J. D. Murray. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., Mar. 21, 7 p.m.

Modular Society

LONDON
"The Way Ahead for the Fabricator," by E. D. Hinchliffe. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Mon., Mar. 18, 7.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
Andrew Laing Lecture on "Structural Steels for Warship Building, with Notes on Brittle Fracture", by Sir Victor Shepheard. Literary and Philosophical Society's Apartments Newcastle-upon-Tyne. Fri., Mar. 22, 6.15 p.m.

Reinforced Concrete Association

EDINBURGH
"Allt-na-Lairige Prestressed Concrete Dam," by J. A. Banks. Scottish Branch. North British Hotel, Princes-street, Edinburgh. Tues., Mar. 19, 6.30 p.m.*

Royal Aeronautical Society

LONDON
"Gas Turbines for Helicopters," by A. W. Morley. Graduates' and Students' Section. Tues., Mar. 19, 7.30 p.m.
"Application of Automatic Digital Computers to Aeronautical Problems," by Dr. S. H. Hollingdale. Section Lecture. Thurs., Mar. 21, 7 p.m.

Royal Meteorological Society

LONDON
Various short papers. Wed., Mar. 20, 5 p.m.*

Royal Society of Arts

LONDON
"Plumbing," by G. L. Ackers. Wed., Mar. 20, 2.30 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Modern Trends in Iron and Steelmaking Refractories," by Dr. H. R. Lahr. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield 3. Tues., Mar. 19, 7 p.m.

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"Materials of Construction in the Heavy Chemical Industry," by F. H. Keating. Mon., Mar. 18, 7.30 p.m.

Society of Industrial Radiology

BRISTOL
"Modern Trends in Non-Destructive Testing," by R. S. Sharpe. Grand Hotel, Bristol. Fri., Mar. 22, 7 p.m.

Society of Instrument Technology

NEWCASTLE-UPON-TYNE
"Choice of Control Settings in Practice," by C. H. Stone. Newcastle Section. Stephenson Building, King's College, Newcastle-upon-Tyne. Wed., Mar. 20, 7 p.m.

South Wales Institute of Engineers

CARDIFF
"The Cynheidre Sinking," by G. Tomkins. Thurs., Mar. 21, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institute of Management, Management House, 8 Hill-street, London, W.1. (GROsvenor 6000.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Diesel Engineers and Users Association, 19 Old Queen-street, London, S.W.1. (TRAfalgar 5597.)
Illuminating Engineering Society, 32, Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Birmingham. (Solihull 1111.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of British Agricultural Engineers, 6 Buckingham-gate, London, S.W.1. (TATe Gallery 8589.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Railway Signal Engineers, Euston House, Eversholt-street, London, N.W.1.
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Liverpool Metallurgical Society, Greenhithe, Grosvenor-road, St. Helens, Lancs. (St. Helens 5879.)
Modular Society, 22 Buckingham-street, London, W.C.2. (TRAfalgar 4567.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's-square, Sheffield 1. (Sheffield 24071.)
Society of Industrial Radiology, 2 Tomswood-terrace, Barking-side, Essex. (HAInault 5488.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)

In Parliament

GETTING TO LONDON AIRPORT

Attention was drawn by Lieut.-Colonel W. H. Bromley-Davenport (Conservative), in the House of Commons last week, to the very large increase likely to take place during the next ten years in the numbers of passengers using London Airport. He pressed the Minister of Transport and Civil Aviation for information regarding the steps being taken to facilitate communications between the Airport and the Metropolis.

Mr. Harold Watkinson said that, when completed, the Cromwell-road extension, in conjunction with the new air terminal at the Cromwell Curve, would reduce the coach travelling time between London Airport and the town terminal to an estimated period of from 30 to 35 minutes, as compared with the present period of from 55 to 60 minutes. Preparations were in hand to widen the Bath Road from its junction with the Great South West Road to the western ramp entrance to the Airport. It was hoped to publish later this year a draft scheme for the first section of the South Wales Radial Road from the Great West Road at Brentwood to the Bath Road between Colnbrook and Slough. This new road would be a motorway, with a spur to London Airport.

In the meantime, the British Transport Commission, having received the survey report of its consulting engineers on the possibilities of a rail link between the centre of London and the Airport, expected to inform him of its views in the near future. He would then be able to decide on the next steps, taking into account the comparative merits of road improvements and of any other proposals currently available, such as those for a monorail connection.

FIRE AT JAGUAR WORKS

The fire which took place at the factory of Jaguar Cars Limited, Coventry (referred to in a Letter to the Editor on page 325) was again the subject of questions. Miss Elaine Burton (Labour) asked the Secretary of State for the Home Department what reports had been received from the Fire Services Inspectorate regarding the disaster. She was informed by Mr. J. E. S. Simon, Joint Under-Secretary of State to the Department, that a report had been received by the Home Secretary from H.M. Chief Inspector of Fire Services, who had expressed his entire satisfaction with the speed of arrival of the fire services involved and who was of the opinion that they had done very well in stopping the fire where they did.

Miss Burton endorsed this view and said that she had heard nothing whatever to the contrary, but she urged upon the Minister the desirability that an official report of the cause of the fire should be published, asking if it were not true that the insulating material used in the roof of the factory was inflammable and that other car factories were stated to have the same sort of roofing. On this aspect, Mr. Simon said that the report made by the Chief Inspector of Fire Services to the Home Secretary related to matters which were particularly within the jurisdiction of the Home Office. In other words, this report dealt with whether the fire services had functioned properly and whether they were in a position to give adequate advice on fire prevention if asked so to do. Other reports had been made, and these were being considered by all the Government Departments concerned, bearing in mind the circumstances which Miss Burton had raised.

NUCLEAR SHIPBUILDING AT PORTSMOUTH?

Matters relating to future developments at H.M. Dockyard at Portsmouth were raised by Brigadier T. H. Clarke (Conservative). He asked the Parliamentary Secretary to the Admiralty if consideration would be given to the construction there of naval vessels propelled by nuclear reactors. Mr. T. G. D. Galbraith, Civil Lord of the Admiralty, replied that representatives of the Portsmouth City Council had recently visited the Admiralty to discuss, among other questions, a suggestion to this effect. The Lord Mayor and his colleagues had been informed that the suggestion would be carefully considered. It was not possible at present to go further than that.

Brigadier Clarke also asked when the proposed extensions to the dockyard were likely to be commenced. On this aspect, Mr. Galbraith said that the nine acres of land now required for extensions were earmarked for that purpose in the Portsmouth Town Plan under the Town and Country Planning Acts in 1948. About six of these nine acres, consisting of blitzed sites, had been requisitioned during the war and had since been in continuous use by the Admiralty. Some three acres of the six originally requisitioned had already been bought and the rest were in process of being purchased. The further development of the extension scheme would take place as funds became available.

SOUND BARRIER BANGS

The Minister of Supply was questioned by Mr. Geoffrey de Freitas (Labour) about the damage caused by a Royal Air Force aircraft to the glass roof of the operating theatre of Southport Infirmary during the progress of an operation.

Mr. W. J. Taylor, Parliamentary Secretary to the Ministry of Supply, said that the aircraft concerned was a P.1 fighter flown by a pilot of the English Electric Company under contract with his Department. The aircraft was headed out to sea where the test was to take place. The pilot was obliged to obtain his position by radio bearings because there was cloud below him. In the result, he passed through the sound barrier five seconds too early and just before crossing the coast. It was not possible to give an undertaking to confine supersonic flying wholly to sea areas, although the Ministry did its utmost to avoid causing damage or inconvenience.

Synthetic Rubber Imports

Information as to the basis of the consultations which were to take place between the United Kingdom Government and the Singapore and Malayan Governments on the issuing of further licences for the importation of synthetic rubber, was sought by Mr. S. S. Awbery (Labour). On this point, Mr. Alan Lennox-Boyd, the Secretary of State for the Colonies, said that the Governments of Singapore and the Federation of Malaya were consulted before a decision was taken on the 1957 import programme for synthetic rubber. It was expected that similar consultations would take place in respect of the programme for next year. These consultations, he added, related to the size of the year's import programme and not to individual applications for import licences.

European Common Market

In the customary discussion last week on coming business, Mr. Bernard Braine (Conservative) drew the attention of the Prime Minister to the need for an early discussion on problems relating to the possible participation of this country in the European Common Market. He pointed out that, since this matter was last discussed in the House, there had been developments, some of them unexpected, which had aroused certain anxieties, especially among Commonwealth producers. Mr. Harold Macmillan said that, while he could not give an immediate undertaking, he would certainly look into the matter, because it was a very important one.

Formation of Euratom

A request for information about the progress being made in connection with the formation of Euratom was put forward by Mr. R. Graham Page (Conservative). In reply, Mr. Reginald Maudling, the Paymaster-General, said that Euratom had not yet come into existence, and the United Kingdom had not entered into any agreement regarding the provision to assist it. This country and the six nations who were negotiating for its formation had been taking part, however, with other countries in Western Europe, in discussions in the Organisation for European Economic Co-operation on Western European collaboration in the field of atomic energy.

Standardisation of Screw Threads

The President of the Board of Trade was asked by Mr. James Johnson (Labour) to make a statement regarding his discussions with the engineering industry about the standardisation of screw threads in the United Kingdom with those in use in the United States. Sir David Eccles said that he had had no special discussions recently with the engineering industry on this subject. Unified screw threads were usually specified in defence orders and were also being used commercially in a number of industries. The Minister expressed a hope that the use of unified screw threads in industry would increase as demands and conditions warranted.

Oil Production in Britain

Oil production from indigenous sources in the United Kingdom, Mr. Maudling said, was likely to be about the same in 1957 as during the past year; a reduction in output by the shale-oil industry being balanced by increases in the production of crude oil, and the production of motor spirit from the low-temperature carbonisation of coal. The Minister informed Mr. G. Nabarro (Conservative) that a good deal of work was taking place on a small but expanding scale in the indigenous production of crude oil.

Shipping Liquid Gas Overseas

Technical progress in respect to proposals for the shipment of liquid gas from oilfields overseas to Britain has now reached the stage at which the Gas Council is considering the possibility of arranging trial shipments. Mr. Reginald Maudling told Mr. Albert Roberts (Labour) that the prospects for these proposals were most interesting and that he considered that these developments were likely to lead to quite considerable benefits to this country in the future. The Gas Council had been doing a great deal of valuable research on this problem.

£2,070 Million for Civil Engineering

A request was put forward by Sir Alfred Bossom, Bt. (Conservative) for an estimate of the amount spent by the nation during 1956 on building and civil engineering works, including such items as roads, docks, and coastal protection schemes, whether by Government Departments, local authorities or private sources. In reply, Mr. Hugh Molson, the Minister of Works, said that it was estimated that £2,070 million worth of building and civil-engineering work had been carried out in Great Britain during the year mentioned.

Graving Dock for Largest Tankers

Replying to a plea by Mr. C. R. Bence (Labour) that the Admiralty should take steps to provide a graving dock on the Clyde to accommodate the large oil tankers now being built there, Mr. Galbraith stated that the provision of a graving dock for commercial purposes was primarily a matter for the shipbuilding, ship-repairing and port interests. The First Lord of the Admiralty was in touch with them.

More Steel for Shipyards

Mr. Paul Williams (Conservative) pressed for a further statement about the supplies of steel to the shipyards. He was informed by Mr. Galbraith that steel supplies to the shipyards improved in the last few months of 1956, making that year's deliveries better than those for either of the two previous years. The First Lord of the Admiralty had had discussions with the Minister of Power and it was hoped that, if the higher rate of recent deliveries could be maintained and increased, the position of the shipbuilding industry would be substantially improved.

THE HUMAN ELEMENT

Answering the Unanswerable Case

Shipbuilding workers will withdraw their labour on March 16 unless the Minister of Labour succeeds in bringing both sides to their senses. There is no doubt that he will try, and a fair chance that he might succeed. But the situation is complex, in part because the shipbuilding unions are tied to the engineering unions in their wage negotiations, in part because the position appears to have changed considerably since the unions stated their claim for a 10 per cent. increase.

The Confederation of Shipbuilding and Engineering Unions backed very readily the demand for a national strike made by the president of the Boilermakers' Society. The employers' " blunt refusal " to consider any wage increase—announced in advance of the claim—has aroused much anger, as evidenced when a proposal to postpone the starting date was heavily defeated. Unexampled prosperity, the unions argue, does not go well with a wage freeze. Order books are full for 4 to 5 years and much more is to come. Foreign competitors' yards are likewise fully booked. Expansion plans and schemes for modernisation have been announced by several companies. Why, then, so intransigent an attitude to a wage claim?

Little can be said in defence of the size of the claim. Some increase is due, but to allow it in full would swell costs in the engineering industry—for who can doubt that the same threats will be made when the engineering unions' turn comes? Yet pressure from the unions should not be entirely deplored. Higher wages may force a general movement towards improved methods, better plant and increased output, which has begun but only in a few places so far. Speaking at the annual dinner of the Institute of Marine Engineers last Friday, Mr. Harold Watkinson, Minister of Transport and Civil Aviation, urged that the industry look again at their methods. He suggested a greater use of machine tools and new techniques such as are employed by the motor industry. But it is the unions' duty, as well as management's, to ensure that the industry is restored to world leadership. A strike could achieve precisely the reverse. The statements of union leaders do not suggest they appreciated this. The boast of Mr. E. J. Hill, general secretary of the boilermakers—" we are satisfied that we have an unanswerable case " ; his threat—" we are not going to be dragged into a court of inquiry or arbitration," and his uncompromising demand for " hard cash " do not suggest that the situation will be easily resolved.

Wandering Journeyman

Workers in the Middle Ages travelled the world to seek experience and the skilled craftsman was much more highly regarded if he had travelled abroad. In this manner the progress made in one country spread rapidly to others. Sometimes, in the building trades particularly, the worker took his skill to other lands. Greek workers helped to build the temple of Baalbek. French masons, working for the master builder William de Sens, built Canterbury Cathedral.

To-day there is once again, after the lull of war and its aftermath, a tendency for workers to go abroad, some to learn new skills and others to teach them. A host of organisations has grown up specialising in exchange arrangements and the results are encouraging. The United Nations Educational, Scientific and Cultural Organisation (UNESCO) published last week the third volume of their study *Workers Abroad*, entitled " The Travelling Journeyman Takes the Road Again," which has been prepared jointly with the International Labour Office. The book contains a review of the present position, and gives statistics for each of the 43 countries who have national programmes of trainee exchange. For each country also are given full particulars of the facilities available, for each organisation and company with schemes of their own.

During 1955 the British Government granted 5,800 permits to foreign nationals wishing to work in the United Kingdom, including technical college and university students on short-term exchanges in industrial and commercial occupations. During the same period over 1,000 workers from Europe have worked and attended courses for one year in the United States. There is every sign that the movement is growing and bringing many benefits to those taking part. Two short chapters, on the reactions of employers and workers and on the problems involved, make useful reading for the individual or the company interested in taking advantage of the facilities available.

Homeless Students

The need for hostels for students at technical colleges has often been stated without much response by anyone. Now the urgency of the need has been recognised by the Government. Lord Hailsham, the Minister of Education, asked local education authorities last week to consider the provision of hostel accommodation at certain technical colleges. He stressed the need to give some of the more advanced students the experience of a period of residence at college. The initial aim should be to allow each student at a college of advanced technology to be in residence for at least a year of a full-time course or for one academic session of a sandwich course

Although the Minister recognises the importance of providing accommodation for students who can attend the college only by living away from home, and for whom accommodation is not available, the basic aim is to provide residential experience. The provision of hostels will therefore be largely confined to colleges of advanced technology or to those providing courses leading to the Diploma in Technology.

Lord Hailsham points out that the duty of providing such hostels—catering for between 50 and 150 students each under the supervision of a resident warden—" lies clearly on local education authorities," not central Government, but expresses the hope that employers who send substantial numbers of students to particular colleges " will consider giving financial help."

Unwanted Retirement

Certain jobs are hard on the years: working at the coal face, in a signal box, on a locomotive or at the wheel of a bus becomes difficult after three-score years. A report published last week by the Nuffield Foundation, entitled *Bus Workers in their Later Lives*, presents the results of an inquiry into " the employment of 300 drivers and conductors from the age of 60 onwards." Mr. F. le Gros Clark, who carried out the work with the co-operation of London Transport, published in 1955 a classification of occupations according to their inherent capacity to employ men in old age. He has thrown a great deal of light on one of the major problems of our times.

About one-fifth of London's busmen have to come off the buses between the ages of sixty and sixty-four, and very few can be kept on after their retirement age. There is no automatic retirement but there are medical examinations and it is only the man of unusually sound constitution who can remain in his job until his seventieth birthday or beyond. Yet few want to retire. The report suggests that in road transport only a small proportion will be able to do so.

Those who opt for light work, usually in bus garages or in offices, are compulsorily retired at 65. The reason is that " light jobs exist, but not in unlimited numbers." Unless some way is found of enabling these workers to transfer to other less physically strenuous occupations well before retiring age, with time to re-train, the wastage is going to be more than the country can afford.

Storm in a Cockpit

The claims of engineer officers for a clearer demarcation of their duties aboard Britannia aircraft operated by B.O.A.C., and for improved facilities to carry them out, did not get a very sympathetic reception from the Court of Inquiry appointed by the Minister of Labour to look into the matter. The engineer officers' union, the Merchant Navy and Airline Officers' Association, argue that the points at issue are purely technical, affecting operational procedures. B.O.A.C. disagree and consider the problem to be one of industrial relations. Pilots from the Britannia fleet told the Court they did not consider it necessary to leave an engineer officer on board, because the engineering duties are so small that the shedding of this load to an engineer officer made very little difference to the work-load of the pilot. The " jump " or centre seat, which the engineers claim should be their own and re-located to give better visibility and access to the aircraft's instruments, should in the pilots' opinion be occupied by whoever the captain considers would contribute most to the efficient operation of the aircraft.

The Court concluded that the whole matter should be re-examined by a working party to be appointed from representatives of B.O.A.C., M.N.A.O.A. and the British Air Line Pilots Association. The Court underlined the difference of view between M.N.A.O.A. and B.A.L.P.A. concerning the need for a specialist officer and, in particular, the pilots' suggestion that engineers should be trained as pilots " in the interests of greater flexibility." It would be a pity if a settlement through compromise introduced rigidity in the operation of the Britannia and sowed discord among crews.

Fatigue is Human

A reminder that long hours spent at work are far from being the only cause of fatigue is contained in a letter to *The Times* by Mr. Alec Rodger, Reader in Psychology at London University. Most of those who have worked at a bench know that doing the same operation for eight hours can be far more tiring than ten or twelve hours of interesting work. Also, few will not have known the light-hearted feeling that comes after a job well done—even the most arduous jobs.

Mr. Rodger was commenting on the new Government order on the flying and duty hours of crews of public transport aircraft, which, he states, " appears to assume that excessive fatigue is almost entirely due to too lengthy hours." He points out that during the past 20 years much knowledge has been accumulated on other determinants of poor air-crew performance. These range " from the number and composition of the have the number and design of displays and controls, and the layout of the flight deck, to personal worries of various kinds."

A happy crew, carefully matched to the job and working in a well designed flight deck, could presumably remain a safe crew for far longer than an unhappy one operating in less favourable circumstances. But who can define the ingredients of good morale, and, even more tricky, who can write them into a document?